THE DEVELOPMENT OF BEHAVIOUR PATTERNS

AND AN ASSESSMENT OF TEMPERAMENT OF

DAIRY HEIFERS

By

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DECLARATION

I declare that this thesis was composed by myself and has not been submitted for any other degree. The work it describes and the ideas it contains are my own unless otherwise acknowledged.

(SHEILA DENNISON)

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ABSTRACT

The main aims of this study were :- 1) to describe the development of behavioural patterns in dairy heifers, 2) to investigate individual differences in behaviour and temperament, 3) to assess the temperament of each during milking and 4) to determine whether measures of early behaviour are related to temperament at a later age or to production measurements.

Time based focal animal samples of twenty Friesian heifer calves over a period of two years recorded the activity of the calf and its nearest neighbour. A study of beef suckler calves reared with their dams was available for comparison of early development. The animals reactivity to being touched was tested approximately weekly and its temperament during milking was assessed. Data on liveweight measurements and daily milk yields were available.

Development of the heifer's behavioural activities is shown graphically, either as proportion of time spent or frequency of occurrence. The development is considered in two ways :- 1)development in relation to chronological age, and 2)development in relation to period of time within a particular rearing condition. However, the development was similar in both cases. Testing of the mean values of the activities for each separate rearing condition, normally experienced by dairy calves during their rearing, showed significant changes. Diagrams of significant sequential changes of activities show the development of the context of these behavioural actions. These

results are compared with those obtained for field calves to indicate where environmental conditions may be affecting the development of the dairy calves behaviour patterns.

The animals were then considered individually. Individual differences in the proportion of time spent in different activities was not consistent in each rearing period. The heifers social profile is represented by histograms of the frequency of expression of two categories of social behaviour, social licking and aggression. Associations between heifers, measured as the most time spent as its nearest neighbour, was only observed between a pair of twins. The reactivity of the heifers to being touched showed that most of the heifers were consistent in their reaction from an early age. Investigation of position within the herd and ease of entry to the parlour during the milking routine showed that heifers were recorded more often in the in the last third of milking group which was also associated with being pushed into the parlour by the dairyman. Investigation of correlation between the behavioural measurements and between the behavioural and production measurements (i.e. growth rate of the heifers and the mean daily milk yield) is discussed. For the behavioural measurements, only the correlation between the frequency of initiating aggression and milking temperament was significant at $p<0.05$ level. However, three other correlations approached significance i.e. correlation of :- proportion of time spent passively as a calf with frequency of initiating aggression, frequency of initiating social licking with proportion of times

pushed into parlour and proportion of times pushed into parlour with milking temperament. This led to the hypothesis of a trend in the development of behaviour characteristics of dairy heifers.

There appeared to be little relationship between the behavioural measures of the heifers and measures of their productivity with only the correlation between frequency of initiating social licking and mean daily milk yield reaching the $p<0.05$ level of significance.

Finally, a discussion of these findings in relation to theories of development(e.g. effect of environment, early experiences) and their implications for animal husbandry is presented.

CHAPTER 1 INTRODUCTION

1.1 GENERAL

Animals have been an inherent part of agriculture since approx. 6000 b.c. (Zeuner 1963, Rouse 1970, Friend & Bishop 1978). Over the years they have become progressively more integrated into agriculture. Gradually, the behaviour of the animals that were kept was observed to identify features which were amenable to handling. This process of continued selection of specific traits has resulted in the domestication of a number of species of animals. In a discussion of domestication and evolution, Hale (1969) identifies seven main behavioural characteristics of a species which favours domestication. They are :-

1)Large social group of hierarchial organisation,

2)Promiscuous matings based on sexual signals,

3)Critical periods in the development of the parent - young bond, with the dam accepting other young soon after birth,

4)Little or no aversive reactions to man or changes in its environment,

5)Omniverous,

6)Limited agility, and

7)Adaptability to a wide range of environments.

Thus the distribution of most domesticated species is confined to a few of the orders. Some biological change in the animal is associated wih the process of domestication. In an attempt to determine the extent of change in the behaviour of the animal observations of the wild conspecifics behavioural patterns in

its natural environment are necessary. From these it is possible to construct descriptive lists of the activities expressed by that species. This is usually termed an ethogram. Comparisons of these ethograms with ethograms obtained from observations of the same species which has undergone selection by man indicates which patterns have disappeared or become modified. Similarly, comparisons of ethograms of animals of the same species in extensive and intensive conditions allows the effect of intensification on the behavioural patterns of the animal to be assessed. These studies can then be used in determining the suitability of these environments in terms of the welfare of the animal.

Due to the increase in labour costs and the decrease in land available to agriculture most farming systems have become more intensive. They have attempted to maintain or increase production from a reduced acreage. Scientific investigations of various aspects of agriculture have aided decisions concerning farming policies. In particular, past research in the dairy industry has investigated various methods of rearing calves (Appleman 1978), types of feeding (Coppock,Bath & Harris 1981) use of pasture and influences on grazing (Hancock 1953) and types of housing and parlours (Russel 1980). The results from these studies have influenced the choice of practices involved in the dairy industry at present. Research and development implications for the future are suggested by Wilson & Lawrence (1984) to cover five main areas of the industry :-

1)Choice of breed - selection on basis of production

traits and efficiency in any particular economic climate.

2)Choice of selection method - to consider multiple ovulation and embryo transfer.

3)Identification of market traits.

4)Nutritional manipulation of milk composition - protection of proteins and specific amino acids, protecting poly-unsaturated fats.

5)Development of new products.

The study of cattle behaviour and its application to cattle management has been extensively reviewed by Arave & Albright (1981) and Stricklin & Kautz-Scanavy (1984). They discuss the available information concerning the effect of environment or early experience on the feeding, sexual, and social behaviour of cattle, and its implications on production. Other authors, such as Hancock (1953) and Tribe (1950) have concentrated on reviewing specific aspects of the animals behaviour, such as grazing behaviour. As Arave & Albright (1981) point out, the early behaviour and subsequent behaviour of dairy cattle has received little attention. In addition to the development of the animals behaviour, both reviews emphasise the lack of knowledge on the development of temperament and whether it is amenable to change.

This project attempted to contribute some information on the development of behavioural activities of the dairy heifer from birth until she enters the dairy herd as a milking cow. It also considered the development of the heifers reactivity in relation to a final assessment of temperament during milking in the

parlour. Finally, these measurements of the individuals early behaviour and emotionality were investigated to determine whether they could be used as a predictor of temperament and/or production at a later age.

CHAPTER 2 LITERATURE REVIEW

2.1 INTRODUCTION

DEVELOPMENT OF BEHAVIOUR

Domestic species of animals used today in animal production systems have evolved to form several breeds with differing genetic potential. These animals have been selected to adapt to changing environmental conditions throughout their development e.g. dairy calves experience restricted housing, loose housing, pasture, and cubicle housing throughout their development. With different breeds being used in similar conditions there will ultimately be differential effects on the developing genotype and, subsequently, on the developing behaviour patterns. Therefore, any genotype - environmental effects on development will be exaggerated by these types of husbandry systems.

Historically, theoretical controversy concerning behavioural development was basically due to the different viewpoints of the two schools of scientists, (biologists and psychologists), involved in developmental studies. Biologists, such as Lorenz and Scott, suggested that the genes were directly responsible for the development of particular behaviour patterns in an almost pre-programmed manner. As an analogy they used the "blueprint" or "circuit diagram" descriptions to illustrate the predetermined concept. To substantiate their theory they used examples of behaviour patterns which were common to all members of the species, "species specific behaviours", such as courtship and maternal behaviour.

Psychologists, such as Hebb, Lehrman, Schneirla and Deneberg, argued that the environment determined the developing

behaviour patterns, especially of those behaviour patterns categorised as psychological behaviours e.g. learning, perception and emotions.

Each arguement involved a division of behaviour into innate and acquired components.This was then focussed into a model interpretating one or other of the viewpoints. Lorenz (1965) gives an illustration of a model based on the assumption that simple relationships would be found between the starting and end points of development (Figure 2.1.1.).

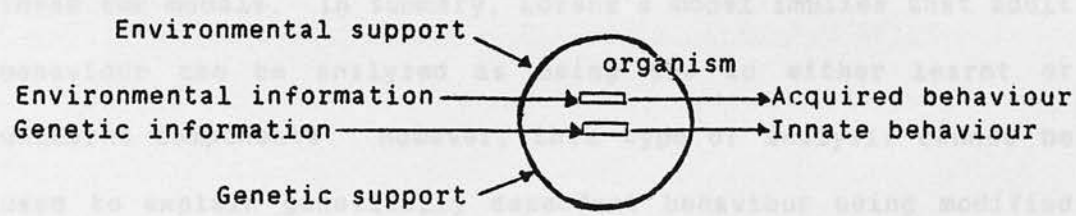


Figure 2.1.1.
MODEL OF BEHAVIOURAL DEVELOPMENT FROM BIOLOGISTS VIEWPOINT

The model (Figure 2.1.2.) suggested by Schneirla (1966) is based on the assumption that the current state of the developing animal influences which genes are expressed and also feeds back onto the external world and influences that i.e. the animal is in a continual state of transaction with its environment.

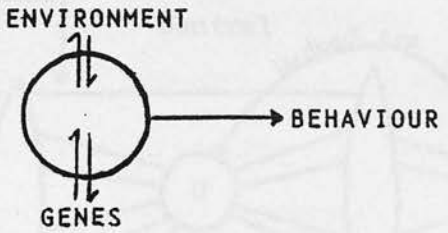


Figure 2.1.2.
MODEL OF BEHAVIOURAL DEVELOPMENT FROM PSYCHOLOGISTS VIEWPOINT

Bateson (1983) discusses the predictions and limitations of these two models. In summary, Lorenz's model implies that adult behaviour can be analysed as being due to either learnt or unlearnt components. However, this type of analysis cannot be used to explain genetically dependent behaviour being modified by learning experiences e.g. bird song patterns and pecking behaviour of young gulls at adults beaks. Whereas, Schneirla's model implies a continuous interaction between the animal and its environment, but it fails to consider sensitive phases for various experiences.

In an attempt to conjoin the two theories, authors such as Dawkins (1982), use the "recipe" analogy, where "the genome is a set of instructions which if obeyed faithfully in the right order and under the right conditions will result in the appropriate behaviour pattern. This is partially shown by the "lens model" for a system of regional reference" proposed by Brunswick in 1956. Petrinovich (1980) modified the model to incorporate previous experience and anticipation of an outcome (Figure 2.1.3.).

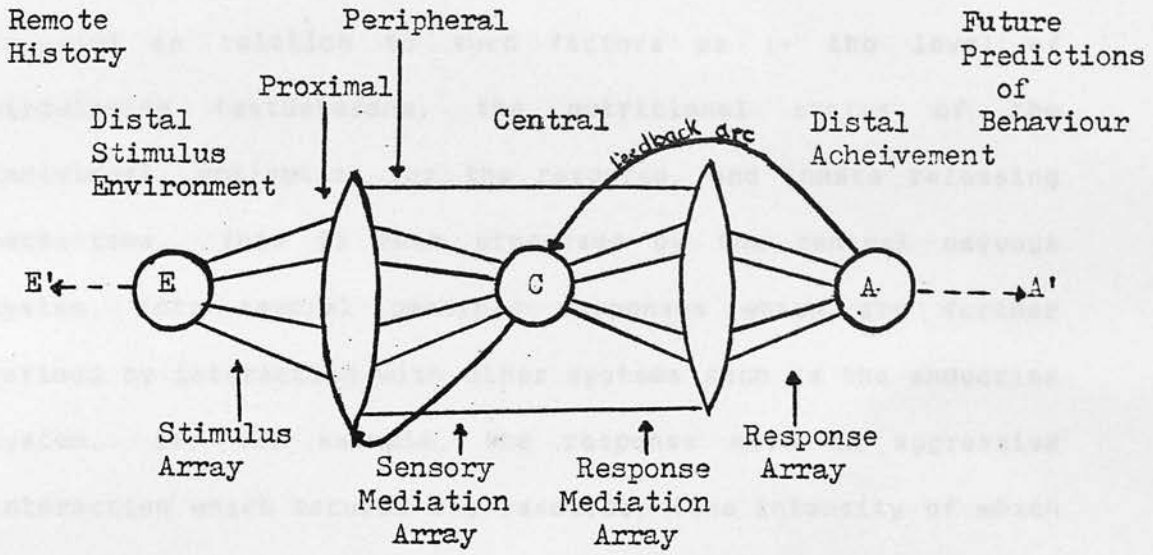


Figure 2.1.3.
MODIFIED VERSION OF THE LENS MODEL PROPOSED BY BRUNSWICK

(from Petrinovich 1980)

The model incorporates the effects of early experiences, the differential effects of the stimulus and the various ways in which the organism can respond to the stimulus. The central region is an inferential one which could include inferential process' such as memory, judgement, perceptives, motives, emotions and expectancy as well as the physical central nervous and endocrine systems. For example, if we consider a resource within the environment which stimulates competitive interaction then early experiences such as rearing conditions could be the "remote history". The stimulus array could involve such factors as :- social density, recognition of postures displayed by the other individuals, intensity of competition, amount and general availability of the resource. These may have different effects at different stages of development. These stimuli are then

focussed in relation to such factors as :- the level of circulating testosterone, the nutritional status of the individual, motivation for the resource, and innate releasing mechanisms. This is then processed by the central nervous system, into several possible responses which are further refined by interaction with other systems such as the endocrine system. If, for example, the response were an aggressive interaction which secured the resource, (the intensity of which may require to be different at various stages in development), then this outcome would be translated back to the central process to mediate or cease the response. This information may be stored in the memory and become part of the "remote history" of the individual at a later stage of development.

Models, such as those described here,are particularly useful in identifying the major variables involved in a theory, thus concentrating thought to the more specific aspects which may be influencing the various connections in the model. These aspects can then be tested experimentally to support or modify the hypothesis.

This dependence on the interaction between genetic and environmental factors on the development of behaviour patterns is the basis of Deneberg's (1972) general model of development :-

"the genetic potential of an organism is present throughout its lifetime, although some genes will not express themselves until quite late. As the genes are expressed during ontogeny, and as their substrates grow and develop, these process'

interact with ongoing experiences (which may be behavioural or biological) to influence each other and affect the animal's future behaviour and biology".

The nature of the stimulation and the animal's ontogenetic age jointly determines the systems to be affected. The "ongoing experiences" mentioned by Deneberg include learning, environmental deprivation or stimulation, nutrition, sex hormones, maternal influences, infantile stimulation and social factors. However, in a study of developmental phenomena the major temporal variable is age, some experiences at different ages have different effects. Embryologists studying prenatal life termed the precision timing of developing process' as critical periods. This was adapted for postnatal development by Scott who proposed that critical periods were present for :- 1) the formation of basic social relationships, 2) for optimal learning periods, and 3) for early stimulation to be effective. Current research data would support Scott's idea for a critical period of socialisation. However, there is not enough data at present to allow adequate evaluation of a critical period for early learning and sufficient data to raise doubt concerning the validity of a critical period for early stimulation. In many cases (see Zolman 1982) differences in the organisms biological or behavioural experiences confuses the issue. Simmel & Baker (1980) suggest that differences in the age at treatment, interval between treatment and testing, and the duration of treatment are all variables which have to be considered in studies concerning early stimulation and learning.

Several studies use the term sensitive phase to describe stages in development when the organism is especially susceptible to environmental influences. This attempts to avoid the finality and irreversibility inherent in the embyological meaning of critical periods.

Deneberg (1962) and Immelman & Suomi (1980) suggest that there are four main developmental periods. They are :-

1)Neonatal - growth and development of behaviour patterns present at birth,

2)Transitional - rapid change and development of new behavioural patterns

3)Socialisation - occurrence of social interactions,

4)Juvenile - begins at weaning and lasts until sexual maturity.

These phases do not have clearly defined start and end points, but appear to be characterised by an enhanced responsiveness of the animal to certain types of stimulation.

Concomitant with the neural and behavioural development of the organism is the development of the animal's physiology. Development in the efficiency of the function of the rumen in the young calf is reflected by an increase in the frequency of ingestion of solid foods such as hay or grass (Swanson & Harris 1958). This activity is present at birth but increases in the frequency of its expression with development of the animals physiology. However, some activities not present at birth become part of an established pattern with the appropriate physiological development. For example, development of the sex

organs and the endocrinology associated with puberty is reflected by the expression of behaviour patterns associated with sexual behaviour. Generally, there is a gradual integration of new behavioural activities into the animals repertoire. It is, therefore, difficult to determine exactly when certain activities take over from others. The behavioural context in which an activity is expressed can be determined from the study of sequences of behaviour. Such studies, over time, on the maturing individual can show the development of a behaviour pattern. For example, mounting in young lambs is often a form of play (Brownlee 1954 and Sachs & Harris 1978) as it is usually within a sequence of rapidly changing, apparently unrelated activities. At a later age it is preceeded by sniffing of the genitalia and followed by copulation. Thus the development of the animals activities is a continuous interaction between the changing individual and its changing environment.

Another developing feature of the individual is it's temperament which, in the case of domesticated animal is usually taken to be it's response to handling. This definition has some drawbacks as several authors (e.g. Seabrook 1972, Albright 1981) have found that many variables e.g. personality of stockman or early rearing conditions, can affect the animals reaction to handling. Also, it is a very restricted definition as it does not take into account intra-specific relationships which may influence an individuals temperament. Thus, a more comprehensive assessment of the animal at various ages and in

various conditions is used in this study as this may be of more value in indicating the genetic - environmental interactions involved in the development of an individuals temperament. This is particularly important for dairy cattle in which the temperament of the mature animal is of economical importance.

THE ASSESSMENT OF TEMPERAMENT IN ANIMALS

A definition of temperament was first attempted by Pavlov (cited by Baryshnikov & Kokorina 1964) using conditioned reflexes to determine the main properties of the nervous system. From his work he suggested that the nervous system was characterised by strength, versatility and balance in the process' of excitation and inhibition. Depending on whether both were present in strength or neither were present in strength, the animal is classified as either "strong" or "weak" type respectively. A balance in the strengths of these process', with the ability to change from one to the other (versatility) is defined as a "sanguine" animal. A summary of the classification is given in Figure 2.1.1.

Figure.2.1.4.
CLASSIFICATION SCHEME OF TYPES OF NERVOUS SYSTEM AS DESCRIBED BY PAVLOV (from Baryshnikov & Kokorina 1964)

Stong Type---unbalanced---impetuous (CHOLERIC)
---balanced ---versatile (SANGUINE)
---inert (PHLEGMATIC)

Weak Type ---------- (MELANCHOLIC)

Balanced animals are capable of adapting efficiently to changes in the environment and their character reflects whichever process has the slightly greater strength i.e. sanguine - lively and excitable and phlegmatic - quiet. Choleric and melancholic animals adapt poorly to changes and are subject to nervous breakdowns.

However, as Valenstein (1970) points out, Pavlov's theory is based on two hypothetical nervous system process' and it is questionable whether all the potential of the nervous system can be summed up by activity of the basic process' of excitation and inhibition. In addition, there is little evidence to show that strength, mobility and equilibrium are independent properties of the nervous system. This type of assessment also deals with the end points of temperament, not the development of temperament which will be one of the main points of this study.

Apart from studies in the U.S.S.R., classification of the nervous system into types for farm animals has received little attention. Most authors studying temperament have used behavioural reactions in specific conditions to classify the temperament of the animal. Making the assumption that few of the reactions observed were independent, they attempted to group

the various reactions into composite descriptions to represent the different categories of temperament. Tulloh (1961) recorded the reactions of beef cattle when they were confined in a weighing crate. He noted the amount of movement, struggling, stubbornness, tail flicking, vocalisation, kicking, butting and the reaction to being handled e.g. quivering. The observations were then summarised to establish six categories of temperament ranging from docile through restless and nervous to aggressive. The main difficulty with this type of assessment is the gradual change from one category to the next. For example, otherwise "docile" animals are classed as "slightly restless" if they appear sligthly stubborn. Gupta & Mishra (1974) applied this type of assessment to milking cows but used five categories, incorporating the "wild" category described by Tulloh (1961) as "aggressive".

Dickson, Barr, Johnson & Weickert (1970) revised Tulloh's type of assessment for their study of dairy cows during milking in the parlour, to four categories of temperament based on the less subjective measurements of movement, kicking, tail flicking and reaction to handling. These activities could be scored as events to indicate when these paricular activities had taken place. This type of assessment involves qualitative measurements, as each, easily identifiable, activity could be scored for occurrence. Thus the reliability between observers would be greater. For these reasons, this type of assessment for milking temperament will be used in this study. Each category was then given a score, rather than a descriptive

title. This method of assessment was used by Albright, Brown, Taylor & Wilson (1975) and Albright (1981), with Donaldson (1970) and Donaldson, Albright & Black (1972) giving more attention to the frequency of kicking, in their studies of milking temperament. Thus data obtained by these authors will be comparable to that obtained by the same method in this study. As most production systems require manipulation of the animals by the handlers, temperaments amenable to handling are an essential attribute in the animal's behaviour. Burnside, Kowalchuk, Lambroughton & MacLeod (1971) exemplify this in their report on the main reasons for culling animals from dairy herds. A knowledge of the relationship between temperament and other production measures is necessary to identify whether culling on bad temperament is justifiable. Several reports, assessing temperament using the methods of Tulloh (1961) or Dickson et al (1970), suggest that docile animals gain weight faster and produce more milk than nervous or active cattle (Stricklin, Wilson, Graves & Cash 1979, Albright 1978 and Arave & Albright 1981). However, further investigation is required on the effect of breed differences (i.e. genetic component), interaction with men and other enviromental factors on the development of an animal's temperament.

A study by Albright (1981) showed that young calves handled from birth developed good milking temperaments as cows. This was interpretated to indicate that these animals were able to respond to the expectations of the handler sooner than others which had not been handled from birth. This study is the only

one which considers temperament from a developmental point of view. However, it is still concerned with developmental effects on groups of animals, not on individual animals. In this study, emphasis will be placed on the developing individual such that, due to the genetic component involved, it may be possible to predict the temperament of the animal from other measures of its behaviour at an early age. This aspect has received little attention as few studies have actually followed the development of the animal's behaviour patterns from an early age to the assessment of temperament in later life.

2.2 DEVELOPMENT OF BEHAVIOUR IN CATTLE

The review of literature presented in the following section endeavours to establish the development of general behavioural patterns of cattle or related species in a natural or extensive environment. This is intended to provide the reader with an expectation of how the behaviour patterns of the dairy heifers in this study should develop. For each stage of development a short review of the information available on dairy cattle is given to indicate where further research is required.

Although basically described in terms of succeeding age periods, reflecting the main developmental periods described earlier, these ages are determined by the approximate age of the dairy calf entering the different rearing conditions normally found on a dairy farm.

2.2.1 Parturition and the Cow-Calf Bond

In wild cattle and related species the onset of birth is marked by changes in the behaviour of the pre-parturient animal. A detailed description is given for beef-suckler cows by Kiley-Worthington & De La Plain (1983). In particular the animal becomes restless and may seek isolation. The extent of isolation sought is dependent, to a large extent, on whether the species is of "hider" or "follower" type.

Most ungulates are classified into two broad types according to the behaviour of the dam and offspring at parturition and post-partum. These are 1) hider and 2) follower. A hider type of species is one in which the newborn animal remains in a

particular location and is visited by the dam for periods of suckling and care. Most deer (impala, roe-deer, red-deer etc.) and cattle species (domestic cattle breeds, Chillingham cattle, Carmargue cattle, Zebu cattle) are examples of hider species. A follower type of species is one in which the newborn animal follows the dam from birth or within a few hours of birth. Examples of this type of animal would include :- reindeer, caribou, moose, wildebeeste, sheep and horses.

Observations of hiders species have shown that the dam calves away from the main herd and that either dam and offspring or just the offspring remains apart from the herd for several days (see Table 2.2.1).

Table 2.2.1. PERIOD OF ABSENCE FROM THE HERD OF DAM AND OFFSPRING FOLLOWING PARTURITION

Author	Species	Period of Absence
Reinhardt(1980)	Zebu cattle	2-10 days (D&C)
Papini(1980)	Macchia Mediteranea	4 days (C)
Hall(1979)	Chillingham cattle	2-12 days (C)
Kelly&Whately(1975)	Red deer	2-18 days (C)
Altman(1952)	Elk	2-14 days (C)
Bubenik(1965)	Roe deer	2-14 days (C)
Espmark(1969)	Roe deer	2-18 days (C)
Rheingold(1963)	Goat	2-10 days (K)

D&C - Dam and Calf, C - Calf only, K - Kid only

This period of isolation is thought to enhance the mutual recognition between the mother and the calf. Some authors(Schloeth 1956, Reinhardt 1980) suggest that the basis of recognition is due to olfactory and auditory cues, with vision becoming involved at later ages. More particularly, Klopfer

(1964), Bubenik (1965) and Hudson & Mullord (1977) state that licking of the calf, which normally occurs immediately after the birth of the calf, serves to promote the specific bond between dam and calf, indicating that olfactory cues are the most important in establishing identification.

A lot of work (Espmark 1969, Kelly & Whately 1975, Edwards & Broom 1982, and Kiley-Worthington & De La Plain 1983) has investigated the behaviour of the dam and calf for varying periods of time after the birth, particularly in relation to parity and udder comformation of the cow (Kelly & Whately 1975 and Edwards 1980), and breed (Selman, Mc Ewan & Fisher 1970). In most cases the mother begins licking the young immediately after the birth. The calf responds by attempting to stand and suckle. The time interval for the above actions appears to vary with the parity of the dam.

Domestic animals appear to be similar in their behaviour at parturition, wherever management techniques allow its expression (Edwards & Broom 1982). Kiley-Worthington & De La Plain (1983) found that in beef suckler cows the isolation of the dam and calf in small pastures was obtained by the aggressiveness of the dam towards other cows which approached them.

On most dairy farms the pre-parturient cow is removed from the group to a calving box where she may calve in spatial and visual isolation. Although this allows the natural expression of behaviour normally seen at this time, it is principally to prevent adoption of the calf by other cows in the group, as observed by Edwards (1980). It also ensures that the calf

obtains colostrum soon after birth. This supplies the calf with a degree of immunity to the diseases on the farm experienced by the cow. This is particularly important as the calf is removed from the dam, usually after a period of 24 hours, and reared artificially with other calves.

2.2.2. CALF HOUSE (approx. age 24-36hrs - 6-8wks)

Ethological studies of elk (Altmann 1956), zebu cattle (Reinhardt 1980 and Reinhardt & Reinhardt 1981), Chillingham cattle (Hall 1979), Maremma cattle (Papini 1980) and beef-suckler cattle (Kiley-Worthington & De La Plain 1983) are useful in determining the behaviour of calves that would normally be exhibited by the wild animal. That is, one would expect the young calf to remain hidden for the initial few days until its locomotory activity was sufficiently developed for it to follow its mother. However, as Altmann (1956) points out, there is considerable variation between individuals in this behaviour. It may be that there is also considerable differences between individuals in other aspects of their behaviour. This phenomena is largely ignored in most of the current research which tends to confine its data to groups of animals. This study will attempt to provide information on the individual animal.

This period of isolation allows the mutual identification between mother and offspring to develop. In most species of deer (Severinghaus & Cheatum 1965, Einarsen 1965, Gilbert 1968) the order of development of the sensory organs in the first week

appears to be hearing, eyesight and then smell. Most young deer quickly learn to respond to the call of their mother. In American buffalo (McHugh 1958), scent is the sense most used for identification when the calf is less than one month old. After this period calves identify their mothers mainly by sight. In zebu cattle voice and scent provide the basis for mutual recognition (Reinhardt 1980). The ontogeny of particular senses in the young calf is not well known but would be expected to be similar to those described above as they have a similar post-natal period of care.

After a few days mother and calf join the remaining group members. In Chillingham cattle (Hall 1979) it is usually the calf which leads the way to the group. Papini (1980) observed in Maremma cattle that after joining the herd the calf interacts only with its mother for up to ten days. After this time it becomes more independent and associates with other calves of the same age (peers) in groups of 4-15 calves. A similar situation was found by McHugh (1958) in American buffalo. Generally the calf interacts only with its dam, but gradually associates with other members of the social group.

Suckling ensures social contact between the calf and its dam. This period of contact, absent in more intensively reared calves, may be the origin of the "licking associations" observed in semi-domesticated zebu cattle by Reinhardt & Reinhardt (1981). All these associations were maintained over a three year period with some still present after five years, showing the persistance of early contacts in later life.

Although Brownlee (1954) suggests that the main reasons for play behaviour are to exercise muscles which would be required in certain circumstances at a later age and for the calf to gain knowledge about its environment, he does not consider the possibility of gaining information about its play partner. Reinhardt (1980) found that play was the main form of social contact between zebu calves. Unlike mithan (Scheurman 1975), domestic cattle have several tactile communications e.g. head butting, pushing, which may originate and develop during play behaviour. From interactions with its dam and other group members the young animal learns the social stucture of the group e.g. leadership, hierarchy. This is particularly exemplified in reindeer in which the calf has the same rank as the dam during grazing (Espmark 1964 and Funk 1981) and in all situations in other cervidae (Altmann 1956, 1958).

During the first six to eight weeks of life the calf is also developing physiologically. Its rumen becomes sufficiently developed to utilize the roughage that the calf ingests while grazing. This fulfills part of its nutritional requirement, the rest is satisfied by increasing the length of time of each suckling period. The remaining time is spent either lying, playing, or idling. An increasing proportion of the time it spends lying is spent ruminating (Nicol & Sharafeldin 1975, Boy & Duncan 1979 and Papini 1980). Subsequently, less time is spent asleep.

In dairy calves the young calf is usually isolated in individual pens in a calf-house and artificially reared using a

replacement milk powder (Owen 1978). Although such separation adequately allows the physiological development of the calf, Sambraus (1980) argues that it prevents the normal social development of the animal. Many studies have investigated the effect of various aspects of this type of rearing on the later behaviour of young calves. Areas of research have covered the effect on :- separation from the dam at various ages (Albright et al 1975, Kovalcik, Kovalcikova & Brestensky 1980 and Edwards 1980), degree of isolation during early rearing, including lack of competitive experiences (Donaldson 1970, Donaldson et al 1972, Albright et al 1975, Warnick, Arave & Mickelson 1977, Broom 1978, Broom & Leaver 1978 and Waterhouse 1978) and artificial feeding (Stephens 1974, Edwards 1980 and Kiley-Worthington 1982). However, none of the studies considers the various adaptations expressed by the individual animals to the confined and barren environments. Therefore, one aspect of this study will be to focus on the differences between individual animals as they develop.

In summary, it can be concluded from the above work that isolation has the greatest effect on the later behaviour of the calf. It appears to affect the ability of the animal to respond to social encounters, competitive interactions especially during feeding, in establishing rank and adult social associations and on the animals maternal behaviour. Production may also be affected, especially where the feeding behaviour of the animal is disturbed. The effect of early rearing conditions however, can be minimised by all the herd members being reared in the

same way.

2.2.3. CALVES GROUPED INDOORS

(approx. age 6-8wks - 6-7 mths)

In most bovidae and cervidae species the young animal remains in contact with the dam until after weaning, which occurs at various ages in different species (see Table 2.2.2.).

Table 2.2.2.
WEANING AGES OF SOME BOVIDAE AND CERVIDAE SPECIES

Author	Species	Age at Weaning
Papini(1980)	Maremma cattle(bovidae)	6 months
Kiley-Worthington & De La Plain(1983)	Beef-suckler cattle(bovidae)	6-9 months
McHugh(1958)	American buffalo(bovidae)	5-6 months
Espmark(1964)	Reindeer(cervidae)	7-8 months
Severinghaus & Cheatum(1965)	White-tailed deer(cervidae)	4 months
Einarsen(1965)	Mule deer(cervidae)	5 months
Altmann(1956)	Elk(cervidae)	4-5 months

The amount of contact with other members of the species, depends largely on the social organisation of the group. At its most extreme, the group may consist only of the dam and calf, or the dam, calf and the dams previous year's offspring, as in moose (Altmann 1958) and deer (Einarsen 1965, Severinghaus & Cheatum 1965 and Gilbert 1968). In other groups there may be several cows with offspring, for example zebu cattle (Reinhardt & Reinhardt 1981) and caribou (De Vos 1960) or there may be cows and calves with yearlings and mature bulls joining the group when the calves are a few weeks old as in American buffalo

(McHugh 1958).

Of the few studies which have investigated the normal social development of domestic cattle, Kiley-Worthington & De La Plain (1983) describe the development of social behaviour in beef calves during the first six months. They recorded the changes in contact behaviour between different groups in the herd, particularly the behaviour governing contact and disengagement in the cow and their calves. They also considered the group structure and recorded the distance between the cow and her calf and any associations with other members of the herd. The study showed that over the first six months of life the calf's contact with its dam remained similar, but it increased the amount of contact with other calves and, after a few months, its contact with other cows. Contact for suckling in the first month was initiated by the dam. After this period the calf usually makes the initial contact. In general, affilitative behaviour was the most predominant form of social contact. However, of specific relevance to this study, they found that individual cows varied in the type of contact between themselves and their calves. For example, calling was exhibited more by certain individuals with others showing more licking and rubbing or smelling. The cows also showed preferences for other individuals resulting in a number of sub-groups within the herd. Reinhardt & Reinhardt (1981) found that calves spent significant periods of time grazing with particular calves of similar age and suggest there may be similar associations during other activities e.g. lying, loafing, walking. However, social licking was not noticed

between any particular pair of animals and appeared to be distributed throughout the group equally frequently.

Rank contests were observed at two months of age in zebu calves (Reinhardt 1980), and four months of age in American buffalo (McHugh 1958). Apart from these early agonistic interactions, most stable groups of cattle appear to have an established hierarchy which does not require constant reinforcement and thus dominance or avoidance interactions are relatively rare (Gilbert 1968, Sambraus & Osterkorn 1974, Clutton-Brock & Greenwood 1976 and Kiley-Worthington & De La Plain 1983).

Altmann (1958) describes five periods in the social development of the moose calf, but as the calf does not have any contact with other moose until after about three months of age it does not accurately reflect the social development of the bovine calf. However, Altmann's study does show that the calf increases its contact with others mainly due to the increase in the frequency of its investigatory behaviour. Murphey, Duarte & Penedo (1981) described investigatory behaviour of cattle as an inverted U-shaped function with age (see Fig. 2.2.1).

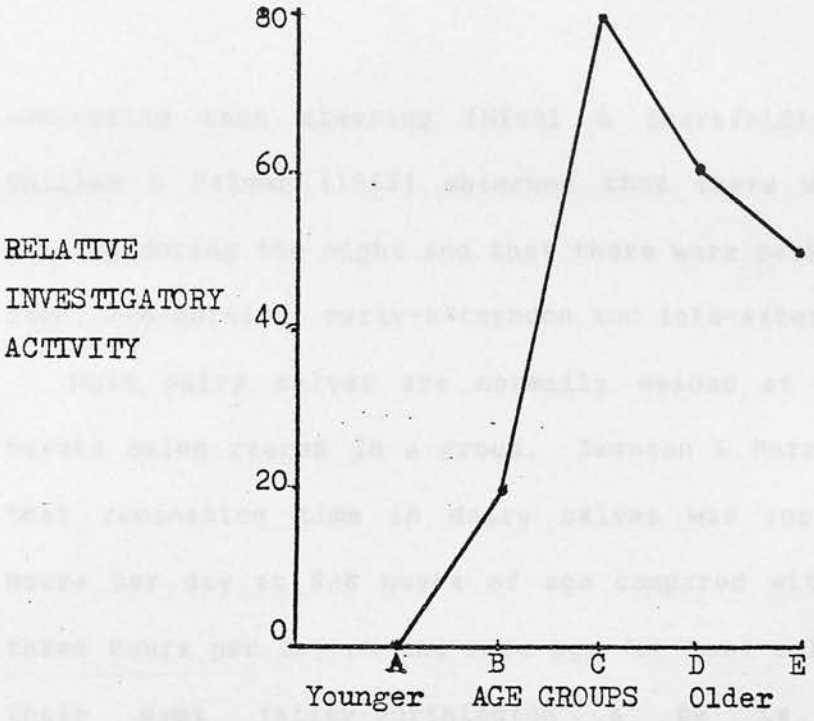


Figure 2.2.1 DEVELOPMENT OF INVESTIGATORY BEHAVIOUR
(from Murphey et al 1981)

That is, when the animal is very young it may be too fearful of the novel stimuli to investigate and that some "maturational level" is reached when the animal is approximately 2-3 years old. Thus, investigation should enable the calf to learn about its environment and other members of its group. Theoretically, this curve is explained in terms of habituation of fear responses and the development of exploratory behaviour as the animals locomotory and sensory capacities develop.

Having started nibbling grass and shrubs from an early age (Wood-Gush, Carson, Hunt and Dennison 1984), the young calf's grazing behaviour continuously develops with the development of its physiological process' of digestion. By 120 days of age the grazing time of beef calves with their dams was approximately equal to 70% of the adult grazing time, and its pattern of lying time was similar to that of cows which spent more of their time

ruminating than sleeping (Nicol & Sharafeldin 1975). Roy, Shillam & Palmer (1955) observed that there was very little grazing during the night and that there were peaks of grazing at dawn, mid-morning, early-afternoon and late-afternoon.

Most dairy calves are normally weaned at 6-8 weeks old, before being reared in a group. Swanson & Harris (1958) found that rumination time in dairy calves was approximately five hours per day at 6-8 weeks of age compared with approximately three hours per day at the same age for beef calves reared with their dams (Kiley-Worthington & De La Plain 1983). Kiley-Worthington (1983) suggests that confined calves may "psuedo-ruminate" to occupy their "spare time". This may be the reason for the greater amount of rumination time recorded for dairy and veal calves compared with beef-suckler calves.

In an agricultural system, as described above, competition for nutritional resources is rare. In comparison, the dairy calf has to compete with other calves for access to the food and water troughs. Providing all the calves have experienced the same initial rearing routine then any adverse effect of a sudden exposure to competitive interactions would be reduced. Detrimental effects occur when calves which have previously been reared in isolation are placed with calves which have been reared in groups and, subsequently, have experience of competition for resources (Donaldson 1970 and Broom & Leaver 1978).

The social experiences of the dairy calf is restricted to those animals of similar age, weight and usually sex. Several

authors, (Scott 1962, Deneberg 1962 and Immelman & Suomi 1980), suggest that there are particular times in the development of the animal when certain experiences are necessary for the normal development of some later behaviour. No information could be found on the effect of lack of experience with other members of the social group e.g. older animals and opposite sex, on the adult social behaviour of dairy calves. However, when the calves become milking cows they are kept in single-sex groups of similar physiological condition i.e. similar stage of lactation. The effect may, therefore, be minimal when considered in relation to that type of management.

Social play in Bovidae increases over the first six weeks of life to a constant level which is maintained over several months (Kiley-Worthington & De La Plain 1983, Wood-Gush et al 1984). Dairy calves first experience social play, e.g. mock fighting, mounting, butting, gambolling, when they are grouped after weaning. No quantitative data could be found for play behaviour in dairy calves at this age. It is possible that it was being classified under social interactions or as investigative behaviour. Broom (1978)b found an increase in the frequency of butting, mounting and pushing in dairy calves after fifteen weeks, but recorded these as social interactions.

The few studies which have recorded the behaviour of dairy cattle after weaning, appear to have been concerned mainly with the effect of early rearing experience on dominance or rank measurements when the animal was between 8-20 months old (Donaldson 1970, Warnick et al 1977, Broom 1978, Broom & Leaver

1978 and Albright 1981). This study will provide some of the information which is required on the overall development of the dairy calf during this period, when social group and management techniques may affect its behaviour.

2.2.4. GRAZING HEIFERS (approx. age 6-7 mths - 11-13 mths)

In natural conditions such as those experienced by wild or feral herds most bovine and cervid calves of this age would be experiencing the process of weaning (see Table 2.2.1. previous), although some wild white Chillingham cattle allow their yearlings to suckle (Hall 1979). As discussed in the previous section the young animal would have developed behaviour patterns similar to those of the adult, with perhaps slight variations in the time they spend lying as Duncan (1980) found in yearling horses and Kiley-Worthington & De La Plain (1983) found in beef calves six months old.

The major influences on their behaviour would arise from encounters with new individuals. In particular, the arrival of sexually mature males to the group (Severinghaus & Cheatum 1965 and Hall 1979) or the increase in group size e.g. winter aggregations (Altmann 1958,1960 and Espmark 1971) will increase the amount of social interactions of the young animal. Either of these events will encourage the formation of peer groups where the young animal associates more with others of a similar age. The bond between mother and offspring still remains as shown in zebu cattle (Reinhardt & Reinhardt 1981), moose (Altmann 1958) and reindeer (Espmark 1971). Indeed moose and

reindeer calves would rarely survive the winter months without their dam whose social position ensures they have access to a food supply.

As a yearling in a separate social group the young animal, increasingly, has to develop its own social position, where previously it was attributed the social rank of its dam. This is usually determined through agonistic interactions such as threat intention movements of the head, threat postures, pushing, butting, or avoidance. However, most of these relationships are reciprocal (Beilharz & Zeeb 1982) with no serious attention paid until the animal approaches puberty. The establishment of dominance - submissive relationships between unaccquainted individuals has been shown in cattle by Bouissou (1974a,b) to occur very rapidly with 84% being settled during the first hour of encounter. Of these interactions actual fighting, in the form of pushing or butting, was uncommon and of short duration. Brantas (1968) found that horned Friesian-Dutch cows took approximately five days to establish relationships. However, these animals also had to become accustomed to a new environment. Both authors found that once determined the relationships were relatively stable.

High ranking animals may benefit from the priority of access to a resource, especially food. Beilharz & Mylrea (1963) and Donaldson et al (1972) observed that low ranking animals moved to avoid a more dominant animal and Syme, Syme, Waite & Pearson (1975) reported that spatial proximity was inversely related to social status. Sato (1982) found that high ranking animals

tended to be found grazing at the head of the moving group (leading) and that low ranking heifers were frequently observed to graze at a greater distance from the group with their heads facing away from the others, or to perform some other activity. In general, it can be concluded that the behaviour of animals lower in rank was affected by the behaviour of higher ranking individuals.

Tribe (1950), Hughes & Reid (1951), Hancock (1953) and Gammon & Roberts (1980) discuss the behaviour of cattle while grazing, and the effects of various environmental factors. In general, only severe weather conditions, such as "cold blustery winds" or "driving rain" altered the animals behaviour, in that the animal ceased grazing, sought shelter and spent more time loafing. During periods of high temperatures the pattern of grazing changed. The cows began grazing earlier and reduced the amount of grazing during mid-day. The quality and quantity of the pasture had a greater effect on the grazing behaviour of cattle. Where the quantity was limited the cattle increased the time they spent grazing. Where the quantity was sufficient, the amount of time spent grazing was inversely related to the quality of the sward. The distances walked by the animal during grazing also varies depending on the environment. An extensive environment will allow the animal to graze over a much greater area and spend more time walking than animals confined in a smaller area, thus the total combined time spent in searching and grazing will differ (Cory 1927, Johnstone-Wallace & Kennedy 1944).

Most grazing occurs during daylight hours, except when these become very short (Hancock 1953). A distinct pattern of grazing, idling, rumination and rest develops, with 4-6 of these cycles throughout the day (Atkeson, Shaw & Foot 1942, Castle, Foot & Halley 1950 and Taylor 1951). On most dairy farms in the United Kingdom the calves are reared indoors for the first six months (Owen 1978). They, therefore, have not yet established the grazing pattern observed by Nicol & Sharafeldin (1975) and Roy et al (1955) for field calves. In addition, the social facilitation of the dams grazing behaviour is absent. Instead the calf learns to eat grass through investigation of the environment. As shown in Fig. 2.2.1. previously, the level of investigation in bovines is high at this age. However, in addition to a new environment, with a new food supply, there may be new individuals added to the group. This provides another source of investigation, but, in this case it is reciprocated (Schein & Fohrman 1955, Brantas 1968) and it may lead to the dominance - submissive types of interactions described by Bouissou (1974a,b). As before, these interactions are usually determined very quickly. In dairy cattle, Schein & Fohrman (1955) and Hafez & Bouissou (1975) suggest that dominance rank is established between 3-6 months of age as this is when most rank contests are observed. But, as Scheurman (1975) reports in mithan calves, younger weaker animals did not observe threats and did not appear to learn to respond until older. Beilharz & Zeeb (1982) suggests that these rank relationships are bidirectional at this time and become unidirectional at puberty.

This period of management of dairy calves, resembles the period under natural conditions in which peer groups become established after weaning and a tentative social hierarchy is forming. Reinhardt & Reinhardt (1981) found that during the formation of peer groups in zebu cattle specific "associations" were formed between individuals during grazing. That is, the animals were observed to be grazing with a specific individual or individuals (its "associates") more often than any others. Kiley-Worthington & De La Plain (1983) also observed preferences for individuals in their study of beef cattle. However, Hook, Donaldson & Albright (1965) found that removal of subjects or introduction of new animals drastically changed the rank order in young heifers. This disruption in the stability of the group may also affect any associations present, especially in those animals being moved to a group with existing associations. Apart from the occasional introduction of new members, dairy calves are usually reared in reasonably stable groups while grazing.

This study will attempt to establish whether investigation levels increase and so encourage the ingestion of grass in the absence of social facilitation from the dam's grazing behaviour. It will also attempt to determine how quickly the calves develop a grazing pattern seen by calves of similar chronological age reared in extensive systems. Another point of interest will be to examine whether bonds which had formed in a previous rearing condition are sustained when proximity is not enforced and whether the choice of partner is more consistent when the space

per individual is increased.

2.2.5. HEIFERS INDOORS (approx. age 11-13 mths - 17-19 mths)

Heifers of this age, grazing in a free ranging herd e.g. zebu cattle (Reinhardt 1980), Chillingham cattle (Hall 1979), would previously have assumed the rank of their mothers. But, as the dam is now concerned with the arrival of her next offspring, the heifer is to some extent alienated from its dam (McHugh 1958). They now interact almost exclusively with their peers. Although bunts and threats are exhibited from about 4-6 months of age little attention is paid until the animals reach puberty. Hafez (1975) discusses the gradual change in the response to these agonistic displays as the animal becomes older. The juveniles form a rank based on the outcome of these interactions. In addition the association between the heifer and the dam becomes re-established during certain activities, usually grazing, resting or social licking (Reinhardt & Reinhardt 1981, Kiley-Worthington & De La Plain 1983). These associations, those between peers, (Tulloh 1961, Syme et al 1975 and Rheinhardt & Rheinhardt 1981) and the relatively stable rank order facilitates the cohesion within the social group. This stability of relationships within the group helps to alleviate the disturbances caused by the hyperactive behaviour of the heifers during the period of oestrus. Heifers in oestrus are restless and change behaviour frequently, moving around, sniffing other animals irrespective of rank and attempting to mount others or standing to be mounted. Normally the heifers would then experience courtship from the bull, followed by

mounting and insemination. These experiences are absent on most dairy farms with the majority of cows being inseminated artificially after observation of behaviour associated with oestrus.

As most dairy animals are reared in single-sex groups of similar age and weight, few of the normal social experiences are present to establish a cohesive group. Instead, experience of agonistic interactions during competition appear to be the main determinants of rank order, even though rank order in heifers was not found to be stable during the first 1-2 years of age (Hook et al 1965 and Beilharz & Zeeb 1982).

Several studies (Guhl & Atkeson 1959, Beilharz & Mylrea 1963, Mc Phee, Mc Bride & James 1964, Bouissou 1972, Sambraus & Osterkorn 1974, Collias 1976, Reinhardt & Reinhardt 1975 and Striclin et al 1979) have found relationships between dominance and age or body measurements (weight, body length, height at withers). These studies have usually based their dominance order on agonistic interactions normally observed during competition for a resource. Competition is common throughout the rearing period of the heifers, but more especially when they are housed in larger groups than experienced previously, with new animals present and feeding of silage replacing grazing. Initially the animals have to adapt to a new environment. They have to learn to walk on concrete and on slatted passages, to lie in areas of predetermined size and position, to eat from specific places and to interact with new individuals. Studies by Albright (1978), Andrea & Smidt (1982), Friend, Polan &

McGilliard (1977) and Friend & Polan (1974) have investigated various aspects of housing e.g. slatted passages, floor covering, number of free stalls and choice of cubicle. Although production is not noticeably affected, behavioural alterations are apparent (Albright & Aliston 1971). Disruption in the sequence of behaviour associated with an intention to lie down is observed in animals unaccustomed to slatted floors, but this can be facilitated by the use of rubber strips on the floor (Andrea & Smidt 1982). Cubicles were found to prevent animals from being disturbed by the movements of others, with an average resting time of 6.8 hours compared with 4.14 hours for loose housing stabling (Bouissou & Signoret 1971). However, more dominant animals used certain cubicles more often than others and low ranking animals did not use these even if they were the only stalls available (Friend & Polan 1975). Thus the resting behaviour of animals in a cubicle system is affected by the rank order. Feeding behaviour of lower ranking individuals has also been found to be affected. Albright (1978) observed that dominant animals kept others away from the feed and water sources. Such behaviour prevents an equal apportion of resources such as food, water and space that Hughes (1977) highlights as desirable features of modern husbandry. However, Leaver & Yarrow (1980) found that low ranking heifers visited the feed face less frequently than others in the group but attempted to stay for a longer period having found a place as it was difficult for a dominant animal to disturb a submissive animal that was feeding at an individual feeding place.

Bouissou & Signoret (1971) found that protection of the head of the animal at the feed trough, by the presence of a partition, allowed dominated animals equal access to the food. This is an important aspect as restriction in access and reduction in average intake increases the variation between individuals, possibly affecting production.

The increase in group size due to the presence of new individuals affects the rank order of the individuals, with an increase in competitive and agonistic behaviour (Broom 1978, a. Hook et al 1965, Bremner 1975, Quick & Grant 1978 and Addison & Baker 1982). Usually, dominance-submissive interactions are decided rapidly (Bouissou 1974a,b). However, during this period the group composition changes frequently with sucessfully inseminated animals being removed to another group and younger animals being added to the group, so that interactions concerning rank are constantly being disputed. No information could be found on the effect of this instability of social organisation on production measurements. However, as this period rarely exceeds five months, towards the end of which the group becomes relatively stable, the effects may not be sustained and be difficult to measure. Towards the end of this period of housing over winter it is hoped that most of the animals have been successfully inseminated. Normal policy is then to group the heifers with a beef-breed bull e.g. Hereford or Angus, so that those inseminations which are unsuccessful can be rectified by the bull, especially after turnout to pasture where frequent observation of the heifers for oestrus behaviour

is not possible. This study will consider the effect of these constant changes and the change in the environment on the behaviour patterns and social relationships of a group of dairy heifers.

2.2.6. IN-CALF HEIFERS GRAZING

(approx. age 17-19 mths - 25-27 mths)

Few behavioural studies have involved animals of this age, most work covering either the period as calves or as dairy cows. The grazing behaviour described in section 2.2.4., is basically the same at this age. However, the actual time spent in any particular activity now closely resembles that of the mature adult, especially the amount of time spent grazing.

In natural groups the heifers would have established their positions within the social hierarchy. The rank orders which had previously been observed as bidirectional or unstable now tend towards unidirectionality (Hook et al 1965 and Beilharz & Zeeb 1982). Reinhardt & Reinhardt (1975) suggest that, in a group of semi-wild zebu cattle, the rank order of the young animal tends to increase with age paralled with a progressive weight gain, until about nine years of age.

Heifers reared on dairy farms do not experience this relative stability in group structure. In particular, the animals are for the first time grouped with animals of older ages and varying degrees of social experience. With each change in management procedure, the heifers have to re-establish their social position. Bremner (1975) observed agonistic interactions

between animals separated for various lengths of time and fights between those in which separation had been the longest. Bouissou & Hovels (1976) found that aggression between animals previously grouped together was lower than those which had not been grouped together. Thus the grouping of the heifers with new older animals, of greater social experience, will result in an increase in the frequency of aggressive behavioural actions. However,most authors (Bouissou 1974a,b, Sambraus & Osterkorn 1974, Clutton-Brock & Greenwood 1976 and Collias, Kay, Grant & Quick 1979) agree that these contests are usually decided very quickly with stable orders being decided within 1-24 hours. Unfortunately, this stability only lasts until the animals approach their expected calving date, whereupon they are removed from the group. Another factor is that often the heifers are grazed in fields at some distance from the farm and then the group is brought back to the farm when they near their calving dates.

In addition to being in a new environment the heifers have to locate the resources within the field, such as the water trough. Leadership by the older animals previously acquainted with the environment and a slight increase in the level of investigation upon entry to the field are thought to be the main factors in locating such resources.

It is possible that dairy heifers adapt to the constant change in their social organisation as no measureable effects on production, (weight gain, calving difficulties, calf weight) have been reported. Indeed, heifers that have the ability to

adapt to these changes may be more able to cope with the management procedures associated with calving and incorporation into the milking herd, discussed in the next section. Investigation of the behaviour patterns of a group of dairy heifers at this stage would be invaluable in providing information for comparison with mature adults, since the heifers have now reached the same state of management, i.e.calving and lactating, as the older cows in the herd.

2.2.7. MILKING COWS

The normal behaviour patterns associated with parturition were described previously for animals in extensive conditions (see section 2.2.1). In modern intensive systems the heifer is usually isolated in individual calving pens. However, the type of rearing condition experienced by the heifer has been shown to affect the expression of behaviour at parturition (Donaldson 1970, Donaldson *et al* 1972 and Edwards & Broom 1982). In particular, heifers that were fed and raised separately as calves cleaned and nursed their calves, but those which had been fed and raised in groups were less protective towards their calves and did not allow them to nurse. These differences were reduced at the next calving. Seabrook (1975) suggests that there is a critical period at parturition for the development of a bond between the heifer and the cowman. Sympathetic treatment of the heifers during this period and the development of stable conditions increases the probability that the cow will react favourably towards him at a later time. Indeed, the effect of

the cowman and in particular his personality has been investigated by Seabrook (1972,1975) and McMillan (1975), who generally agree that those people who are fond of the animals and who the animals respond to by moving towards them obtain the best milk production.

Normally after calving the heifer would develop the bond between her and her calf (Hudson & Mullord 1977 and Reinhardt & Reinhardt 1975) and resume her established position within the social hierarchy of the herd (Dickson et al 1965, Sambraus & Osterkorn 1974, Syme et al 1975 and Rheinhardt 1980). Unfortunately, on intensive dairy farms, the bond between the heifer and her calf is disrupted 24-36 hours after calving. The calf is removed to an artificial rearing unit and the dam joins the milking herd. Here she is exposed to a group of animals of similar stage of lactation, but of mixed parity. A few of the group members will be identifiable by the heifer but the majority will be unfamiliar. In addition, the environment is unfamiliar, with a wide variety of new noises, especially in the milking parlour. A stable relationship between the heifer and the cowman will facilitate handling during this time.

Albright, Gordon, Black, Dietrich, Snyder & Meadows (1966) showed that cows could be trained to auditory cues to enter the parlour in a predetermined order, but without constant reinforcement the more aggressive cows entered first. Order of entry to the parlour has been a subject of interest to many authors (Dietrich, Snyder, Meadows & Albright 1965, Albright et al 1966, Seabrook 1972, Reinhardt 1973, Soffie, Thines &

Marneffe 1976 and Rathore 1982). In most studies a systematic order was observed, but they tended to conflict in their explanations for the order. Correlations between order of entry and udder pressure, social position or dominance related measurements and milk production have been reported with few authors obtaining correlations between similar measurements.

It is during this period that the temperament of the animal is critical in determining her adaptability to the stresses to which she is subjected. Baryshnikov & Kokorina (1964) use Pavlov' theories of temperament to define the temperament of the individual animal and the qualities of which will enable her to adapt to the stress of being milked. They, like other authors (Scott 1958, Dickson et al 1970, Donaldson 1970, Gupta & Mishra 1974, Albright et al 1975, and Albright 1981) attempted to correlate temperament with production. In their study, they found that cows exhibiting "strong balanced, versatile type of nervous activity" adapted best to milking and produced significantly more fat and milk yields with a higher persistency of lactation and little variation in daily yield than those categorised in the other temperaments. Temperament assessments based on observations of the behaviour of the animal as categorised by Tulloh (1961) and Dickson et al (1970), described previously, differ in their findings. Gupta & Mishra (1974) found significant correlations between milking temperament and milk yield measurements, let down time and milking time, whereas Dickson et al (1970) found no correlation between temperament and milk production. Investigations of the effect of rearing

condition has shown that calves removed from the dam at birth were more docile during milking and easier to milk than those left with their dams for periods up to 72 hours (Albright et al 1975 and Albright 1981). However, rearing in groups or in isolation had no effect on temperament (Donaldson 1970 and Donaldson et al 1972).

In addition to learning the routine of milking and habituating to the various noises associated with milking, the heifer has to learn about other members of its social group. Once again she has to establish her social position. The disruption of the groups activities following introduction of a new member is reflected by an increase in agonistic or aggressive interactions (Bremner 1975, Quick & Grant 1978, Collias, Kay, Grant & Quick 1979, Hart 1980 and Addison & Baker 1982). It is usually of short duration (2-24 hours) depending on the previous experience of the heifer in having to establish her rank position in a relatively new group of individuals (Bouissou 1974a,b and Collias et al 1979).

Introduction of new animals to a group or moving animals between groups principally affects the behaviour of the individuals. Although some authors found a decrease in milk production (Schein & Fohrman 1955, Brantas 1968 and Brakel & Leis 1976) others found no effect on production after movement of animals (Quick & Grant 1978 and Collias et al 1979).

Fortunately, the heifer's previous experience of cubicles and silage feeding from a trough, described in section 2.2.5., enables her to adapt quickly to the environment in which she is

now managed. Eventually the ultimate group size, determined by the type of management and size of buildings, will be reached and there will be a period of relative stability of the group members and routine of management, allowing the heifer to adjust to her new life as a milking cow.

SUMMARY

Little information is available on the continuous development of most of our domesticated species and, as shown in this review, on dairy cattle in particular. A study of the development of behaviour patterns could be used to investigate whether domestication had changed the range and expression of behavioural activities observed in wild bovines. However, this would require the animal to be in conditions where it had the opportunity to express its entire repertoire of activities in a normal way. Information from pigs (Stolba & Wood-Gush 1980) suggests that domesticated species still retain all the behaviour patterns expressed in the wild.

Alternatively, assuming that the animal is capable of developing and expressing its behaviour patterns in a similar manner to wild related species, the study could attempt to assess the effect of the environment, physical and social, imposed on the animal. As shown in the review, this leads to the identification of several aspects of behavioural development which could be affected, in a specific or more general manner, by the various rearing conditions.

The following points are of specific interest, having recieved little attention in the past:-

1)As the initial rearing conditions for dairy calves are, usually, the most "un-natural" period of their rearing, what effect does this have on their behavioural development, especially in comparison to calves of similar age reared with

their dams in extensive or semi-extensive conditions ?

2)Most studies of behavioural development centre on the results of a group of individuals. How similar is the individual behavioural development of calves ? Also, how does each individual adapt to the confined and barren conditions of an individual pen ?

3)The rearing conditions subsequent to the calf-house become less restrictive physically, but how does the social environment and its manipulation through management procedures affect the behavioural development of the heifers e.g. the lack of social learning from adults about resources, or development of social preferences or relationships ?

4)Previous assessments of temperament have investigated relationships between measures of temperament and levels of production. It would be interesting to determine whether a measurement of temperament e.g. during milking - "milking temperament", is related to other aspects of the individual's behaviour, e.g. strategy of adaptation to restricted conditions.

The study which follows is basically a longitudinal study of the development of behaviour patterns of twenty dairy heifer calves with an assessment of their reactivity throughout the study and, eventually, during milking in the parlour. It is intended to provide sufficient information to attempt to answer some of the questions outlined above. However, it may only be possible to partially answer some of the questions due to the restrictions of the management routine imposed on the study.

CHAPTER 3 MATERIALS AND METHODS

3.1. INTRODUCTION

As the calves were autumn born they were initially housed before being put out to graze. This schedule of housing and grazing is repeated throughout the life of the animal. It is proposed here to divide the periods of study into those when the calves were housed and those in which they were in the field. The initial period of housing is further subdivided into periods because of differences in environment and/or social grouping of the calves. As the rearing condition is thought to influence the development of behavioural patterns of the calf (Donaldson 1970, Albright 1981), the management procedures involved in each period are described. This is followed by a description of the experimental procedure. However, as this remained basically the same throughout the study, it will be described in detail in the first section, with reference to this and any modifications included in the subsequent sections.

A pilot study of approximately four weeks was undertaken to become familiar with the method of sampling and to observe the behaviour patterns found in dairy calves and cows. During this period it was also attempted to identify the effect of an observer being present by mounting a video camera over a pen to record the activities expressed by a calf when an observer was not present. This was then compared with a study taken at a similar time with an observer present. However, it was impossible to position the camera such that all the activities performed by the calf could be observed clearly and accurately from the recording. Thus, it was decided to adopt the procedure

of direct observation of the calves, allowing a period of time for the calves to become accustomed to the observers presence. This was calculated by noting the calves activity before completely entering and waiting until the majority of animals had resumed this activity, usually between 10 to 20 minutes. From these observations a list of the behavioural activities observed was compiled (see Fig 3.1.1.). A descriptive account of these activities can be found in the results section.

Fig.3.1.1. BEHAVIOURAL ACTIVITIES RECORDED

Initial letter L - Lying, S - Standing

Abbreviation	Activity
LAP	Asleep
LR	Resting
LLA, SLA	Looking around
LOB, SOB	Looking at observer
LIg, SIg	Ingesting
LCu, SCu	Ruminating
LShk, SShk	Shaking head or body
LN, SN	Nosing inanimate object
LLiObj, SLiObj	Licking inanimate object
LRub, SRub	Rubbing body against object
LSA, SSA	Licking its body
LLiN, SLiN	Licking its nose
SId	Idling
SDr	Drinking
SGrz	Grazing
LNCalf, SNcalf	Nosing or licking a peer
NbyCalf	Nosed or licked by peer
PushCalf	Push or rub against peer
PushbyCalf	Pushed or rubbed by peer
Agonistic	Buts or Butted by peer
Move	Moves forwards or backwards, stands up, lies down, turns round
Run	Trots or gallops
HLegScr	Hind leg scratch
Jump	Jumps or frolicks
Stretch	Stretches body
Mount	Mounts or is mounted by peer
Voc	Vocalises
Urin	Urinates
Def	Defecates

3.2. MANAGEMENT AND EXPERIMENTAL PROCEDURES

3.2.1. PARTURITION

(i)Management

The dam was housed as part of a group in a large straw-bedded yard before parturition. She was then moved to an idividual calving pen before the onset of calving. A complete diet was fed ad libitum (i.e. silage + minerals + vitamins + concentrate food) and water was always available. During this period she was observed regularly, by the stockman, for any difficulties and prolonged calving time.

After birth, the calf and cow were left alone in the pen for at least six hours, following which the stockman would check that the calf had obtained colostrum. If suckling had not taken place then the stockman would hold the calf at the teat to ensure it had suckled.

(ii)Experimental

The birth of the calf was observed wherever possible for each of the twenty heifer calves which were used in this study. Figure A1 of Appendix A shows the record which was taken at the birth. The aim of these observations was to identify possible early experiences by the calf which may affect it behavioural patterns at a later stage in its life. However, some calvings were completely unobserved as they occurred after the last observation at night and before the first observation in the morning. The black and white markings of the calves were recorded to enable identification and these can be found in Appendix A.

3.2.2. CALF HOUSE

(i)Management

The calves were removed from the dam at a minimum of twenty four hours post - partum. This was to ensure that the calf was seen to have obtained colostrum from its mother. Upon entry to the calf house the calf underwent the following procedures :- (i)Weighing, (ii)Ear-tagging, (iii)Removal of excess teats and (iv)Spraying of the navel with Orramycin. The calf was then placed in a pen. A diagram of the layout and dimensions of the calf house and pens is given in Appendix B. Twice a day the calves were fed with "Easy-Mix Volac" milk replacer. The calves received approximately one gallon of warm milk per day by the end of one week of age. Water was always available from a few days of age. "80CM Silcock Calfwena Quicklets" were fed ad libitum and hay was always available after the calf was a week old. The calves remained in these pens until shortly after abrupt weaning. They were then weighed and transferred to group pens.

(ii)Experimental

As this study was primarily interested in the behaviour patterns of individuals, recording of observations was based on the focal animal sample method reviewed by Altmann (1974). That is, following a predetermined random list, the calves were observed individually and their behaviour recorded continuously for fifteen minutes. However, the time spent in various activities by the calves was also required. Scan sampling of the group i.e. recording the activity of each animal in the

group at various time intervals, is normally used. In this study, due to the constraints of the building and the locations of the group members, this type of recording was not possible. Therefore, a time scale was added to the focal animal samples. This was achieved by taking a record of an electrically controlled bleep emitted every 30 seconds. Thus, these time-based focal animal samples can be used to estimate the duration of an activity and the frequency of its expression.

In the first instance, the observations were recorded using a Sanyo TRC50 cassette recorder. The tapes were then transcribed onto record sheets. A typical record sheet can be found in Appendix B. These were then coded for data processing onto computer files.

Each calf was observed for 30 minutes after first being put into the pen. Thereafter, as many 15 minute observations as possible were recorded. The observations were distributed as evenly as possible during the period 0800 to 1800 hours. Unfortunately, the calves were born over a two month period so that the number of calves in the calf house was not consistent. Priority for observation was given to the younger calves whose entry to the calf house was more recent.

In addition to these observations, the calves reactivity to being touched by the observer was recorded once a week and assessed on a point scale as given in Table 3.2.1. In the calf-house, the test was conducted by approaching the animal and extending an arm until the hand came into contact with the forehead of the calf. The hand was left in position for

approximately 30 seconds before being removed. If an individual moved away, then the arm was left extended for approximately 30 seconds. A few words were spoken quietly throughout the period of the test. Each individual was, usually, tested when it was facing the observer so that it was aware of the observers presence and could see the attempt to touch. The scale was chosen, arbitarly, to reflect the reactions of the calves i.e. a negative score for a negative or aversive reaction, a score of zero for little or no reaction and a positive score for a positive reaction. Weekly replicates of the test appeared to be the best compromise between obtaining a large number of replicates within a particular rearing period and the animals becoming familiar with the test.

Table 3.2.1. REACTION OF CALVES TO BEING TOUCHED

Reaction	Score
Moves away and cannot be coaxed	-2
Moves away but can be coaxed easily	-1
Does not move away or come forward	0
Allows touching and tries to suck or rub against observer	1
Allows touching and respond by moving forwards for more	2

3.2.3. WEANED HOUSED GROUPS

(i)Management

The calves were grouped approximately according to weight after weaning. However, the availability of group pens was a limiting factor. The calves were placed in several different pens and group consistency was altered due to differences in pen sizes. The dimensions and layouts of the various pens used are given in Figures C1a-f of Appendix C. Table C1 of Appendix C shows the composition of the group in the pen at any particular time. The calves were fed Langhill grower concentrate food (1kg/day/calf) plus hay ad libitum. Later, at approximately 5-6 months of age they were transferred onto ad libitum silage, but concentrate food was still given at the previous rate.

(ii)Experimental

The focal animal samples, described previously were continued throughout this period for the group of twenty calves observed from birth. The assessment of their reactivity to being touched was repeated each week. As the animals could now move some distance away from the observer the same procedure was adopted at each test. That is, the animal being tested was approached, followed by extension of the arm as described previously. If the animal moved away then the arm was left extended for approximately half a minute before a maximum of three steps forward were taken. A few words were spoken quietly during the test. The calves reaction was then categorised into one of the five scores shown previously in Table 3.2.1.

3.2.4. GRAZING PERIOD 1

(i)Management

The calves were moved from the building when they reached approximately six months of age. With the result that those under study were moved in small groups at different dates. Initially all the calves were moved to the "Two-Acre" field(1) next to the old buildings. From then onwards they were moved around the following fields :- (2)"Steading+Bumlies", (3)"Dryden Garden", (4)"Moat Cottage", (5)"Garden Cottage", (6)"Poultry Research Centre", (7)"South Road", (8)"Dryden+Garden Cottage", (9)"Annies Knowe", (10)"House Field", (11)"Pit Field" and (12)"Longrigg". A brief description of each of these fields can be found in Appendix D.

The composition of the groups grazing the various fields changed during the summer season and this is shown in Table D1 of Appendix D. Unfortunately the experimental group was reduced to nineteen animals during this period due to the death of calf F169 with pneumonia.

Other management practices invólved spring weighing before turnout, placing fly-repellent ear tags on a group of heifers which included calves F130 to F138 of the experimental group, dosing for worms and midsummer weighing of all the animals. The feeding of concentrates at approximately 1Kg/calf/day was continued throughout the grazing period.

(ii)Experimental

The experimental procedures involved at this stage were essentially a continuation of those previously described in earlier sections. The fifteen minute focal animal observations were carried out at various times, between 0830hrs and 1700hrs. The general weather conditions e.g. sunny dry warm, cloudy wet cool, during each recording was noted. As before, the nearest neighbour to the focal animal during any particular activity was recorded and the calves reactivity to being touched by the observer was tested once a week.

As the heifers were now in an environment in which they had the opportunity to express their individual behaviour without the constraints of a housing system i.e. enforced proximity and provision of food in localised areas, it would be interesting to determine the degree of synchrony between the animals in their activities and any preference of specific individuals as neighbours. This was attempted by recording the identity, position and activity of each animal in the group onto a prepared sheet of concentric circles which were approximately one calf's length apart. The centre was designated as the focal animal. However, the size of the groups varied between 20 - 35 animals, the majority of which were not members of the study group. Thus identification of each animal was very difficult and took considerable time. This resulted in several individuals being recorded repeatedly on an individual scan whenever the animals were active and moving around e.g. during grazing. The information was, therefore grossly inadequate and

time consuming and for these reasons these scan samples were discontinued. Had the group size been restricted to the twenty heifers of the study group, whose identity was familiar to the observer, the information could have been recorded quickly and accurately. This would have provided a more detailed insight into the development of social cohesion within the group.

3.2.5. HOUSED HEIFERS

(i)Management

In November 1982, the heifers were brought in, weighed and housed for the winter. The heifers were put into a cubicle and yard system with ad libitum silage available from the silage face. They were also fed concentrate (Langhill Grower) at approximately 0.5Kg/heifer daily. There were two types of cubicles available :- i)wooden-based cubicle with solid passageway (11 places), ii)concrete-based cubicle with slatted passageway (41 places). The stalls were bedded with sawdust weekly and the yard was cleaned every second day. A diagram of the building layout can be found in Fig. E1a. of Appendix E. During this period, the heifers were observed for oestrus by the stockman and those in "heat" were artificially inseminated. After a maximum of two inseminations the heifers were moved into the group of older heifers and cows where the Hereford bull (87) was present to mate with any heifers which did not become pregnant to the artificial inseminations. The housing arrangement for the group containing the bull was similar to that previously described. The main difference was the

provision of twenty eight wooden-based cubicles as opposed to eleven. A diagram of this building layout can be found in Fig. E1b. of Appendix E. By the middle of April 1983 all the heifers were in the section with the bull prior to turnout at the end of April. The group composition during this period of housing can be found in Table E1 of Appendix E.

(ii)Experimental

To ease identification of the experimental group, colour-coded collars were put on the heifers during weighing. Focal animal observations of the group, as described in section 3.2.2., were continued. Sampling was distributed as evenly as possible between observations in the cubicle area and observations in the yard area outside. The nearest neighbour, during each activity or change of activity of the focal animal, and weather conditions(when outside) were also recorded. The reaction of the heifers to being touched by the observer was tested weekly.

3.2.6. GRAZING PERIOD 2

(i)Management

After being weighed the heifers were turned out for the summer grazing period at the end of April 1983. They were grazed in fields at Mortonhall and Fairmilehead, several miles from Langhill farm. The farm staff checked and fed the animals daily, giving the heifers approximately 0.5Kg/animal/day of concentrated food. Initially they were confined to either the top or bottom field at Mortonhall, but after a few months they

were allowed access to both fields. For a short period of time a group of seventeen heifers, three of which were part of the study group, were grazed in the field at Fairmilehead. In August 1983, all the animals were sprayed for lice and the heifers diagnosed for pregnancy and expected calving date by a veterinary surgeon. Those which were due to calve, mostly the older animals in the group, were removed and transported back to Langhill farm. Throughout the grazing period animals were periodically removed either for sale or because they were due to calve. By September, all the heifers were returned to fields close to the farm. A brief description of the fields at Mortonhall and Fairmilehead are included in Appendix F. Towards October, the heifers were in a field close to the main buildings and they were allowed access to silage in a food trough. The group composition changed frequently during the grazing period as cows and heifers due to calve were removed and other heifers added to the group. A summary of the group composition over this period is given in Table F1 of Appendix F.

(ii)Experimental

The focal animal samples described previously were continued with a record of the nearest neighbour and weather conditions throughout the samples being taken. The reactivity of the animals to being touched, describred in section 3.2.2., was tested approximately weekly.

3.2.7. HOUSING BEFORE CALVING AND INCORPORATION INTO THE MILKING HERD

(i)Management

Eventually, all the heifers were transferred to the yard they had been kept in the previous winter(see Fig. E1b. of Appendix E for a description of the yard with cubicles and access to the silage face). The animals remained in this area until approximately one week before calving. At this time they were removed to a straw-bedded covered yard for closer observation. A day or two before the expected day of calving the animals were removed and isolated in a calving box, identical to the one they had been born in. Table G1 of Appendix G shows the dates of calvings of the study group. After 1-2 days the heifers then joined the milking herd. The herd is managed in three sections reflecting the stage of lactation i.e. early, mid or late lactation and a fourth section which was involved in a feeding trial. These are classed as milking groups one to four respectively, and are brought separately to the parlour for milking. The heifers in this study were grouped with other newly calved animals in early lactation in either of of groups one or four. The heifers were grouped with other newly calved animals in early lactation. The size of the group was limited by a combination of the number of cubicles, feeding places and area in which they were managed. There was usually a maximum of 48-50 animals in each group.

(ii)Experimental

As the first heifer of the study group to calve did so at twenty five months of age, the focal animal observations were discontinued when each animal reached this age. Following calving, the behaviour of the heifer was observed in the collecting yard before and in the parlour during milking. The heifer's position as she entered the parlour and the ease of its entry was recorded. During milking, the heifer's reaction to being in the parlour, during preparation for milking and during actual milking was noted. The observations of behaviour in the collecting yard and in the parlour were recorded directly onto prepared sheets, an example of which can be found in Appendix G. These records were then used to assess the animal's temperament during milking. The temperament score was based on the categories used by Dickson et al (1970). This is shown in Figure 3.2.1..

Figure. 3.2.1. ASSESSMENT OF MILKING TEMPERAMENT

(from Dickson et al 1970)

DESCRIPTION OF TEMPERAMENT	SCORE
Very quiet; never gives any trouble; extremely docile during milking and preparation;	1
Stands quietly in stall; not bothered by preparation or milking; but may move frequently, shifting weight from side to side; may flick tail occasionally; gives very little trouble;	2
Generally quiet, but moves around a lot; may lift feet occasionally during preparation or milking, but does not kick; flicks tail frequently or appears restless occasionally;	3
Appears very restless during preparation or milking; kicks at handler occasionally; steps from side to side a great deal; quivers when a hand is placed on her.	4

The observations of the animals in the milking parlour were taken over a period of 4-6 weeks following calving. Unforunately, some heifers of the study group were sold before or shortly after calving with the result that only thirteen of the original animals were observed during milking.

3.3. METHOD OF ANALYSIS

The data collected was analysed to answer four main questions:-

1)Are there changes in the time devoted to particular behavioural activities as the calf develops?

2)Are there consistent individual differences between the calves, in terms of how they spend their time, which animals they spend their time with and how they interact with other animals?

3)Do the calves differ in their development of reactivity or temperament?

4)Are there any relationships between the measurements of behavioural activities, indicating their possible developmental trend, and are they correlated to production measurements i.e. growth rate, mean daily milk yield?

The Genstat computer package was used to sort and tabulate the focal animal data for further analysis. Programmes written in Fortran and Imp programming language were used to analyse sequences of behaviour. While the graphical computer package "Easygraph" was used to construct graphs showing the development of behavioural activities and the development of the animals reactivity to being touched. The analysis is basically descriptive. Changes in the development between each rearing condition were tested with an appropriate statistical test. Non - parametric statistical tests described by Siegel (1956) were used when the data were not normally distributed, otherwise statistical tests applicable to a normal disrtibution were used.

A full description of the analysis performed, statistical tests used and the results obtained are presented in the following sections which attempt to answer the questions outlined above.

CHAPTER 4 RESULTS AND DISCUSSION

4.1. ETHOGRAM FOR DAIRY HEIFERS

The behavioural activities observed for the heifers are described in detail here.

(i)Standing - The animal is upright with all four legs on the ground and its weight equally distributed. Its head is held in the normal position of about ninety degrees to its neck.

(ii)Lying - The animal lies down by first putting its weight forward onto its knees of its front legs and then folds its back legs down under its body before lowering its body to the ground. The animal usually lies more to one side than the other.

(iii)Resting and Sleeping - This usually occurs while the animal is lying. During sleeping, the head may rest on its flank and the heifer may occasionally sleep prostrate on the ground. In both activities the head is held close to the body at an angle of less than forty-five degrees to the neck with the ears close to the side of the head and the eyes are usually closed.

(iv)Observation - occurs when the animal is lying or standing. The head and ears are orientated towards the object of stimulation e.g. observer or the head may move around in general observation.

(v)Ingestion and Grazing - Ingestion of concentrated or preserved foods such as silage is by gathering up a mouthful of the food with its tongue followed by a limited amount of chewing. During grazing, the animal bites and tears off a mouthful of grass which it then swallows without much chewing. The animals head is usually in close proximity to the ground between each bite and the animal may step forwards during this

activity.

(vi)Rumination - This is the process of regurgitation, chewing and swallowing of the previously ingested food. This is most commonly observed when the animal is lying down.

(vii)Investigation - This is expressed by the animal sniffing an inanimate object with its nose and is usually accompanied by repeated licking of the object. The ears are usually pricked forwards towards the object.

(viii)Grooming - This is shown by the animal licking various parts of its anatomy or rubbing its body against some feature of its environment with a repeated to and fro movement. It may also scratch itself by using its hind leg, particularly to scratch its head and neck.

(ix)Play - This is mostly observed in young animals. In the dairy heifers it was expressed by the calf jumping up and down with all four feet off the ground at one time. It occasionally turned around during the leap and was often accompanied with shaking its head from side to side or up and down. The activities were usually of short duration and began and ended abruptly.

(x)Agonistic - This is expressed by several actions. Threat intentions are shown by positioning the forehead forwards towards the other animal with the back straight and the weight forward. Submissive animals generally respond by lowering their heads and / or exposing their flanks. Pushing and butting are usually directed towards the flank or rear of another animal with a forward movement of the forehead. A more detailed

description of these activities can be found in Hafez (1975).

(xi)Walking and Running - Walking is a four paced gait involving alternate fore and hind legs. The sequence of movement is :- near fore, off hind, off fore followed by near hind. Running can be either a faster version of the walk or resembling the two and three paced gaits of the horse i.e. galloping and cantering.

The development of the expression of these activities for the group of dairy heifers in this study, reared on a typical dairy farm, is now described in the following sections.

4.2. BIRTH STUDIES

It was only possible to obtain a record of the activity of calf and dam shortly after birth for ten of the calves involved in the study. Thus, the information was reported in a qualitative, rather than a quantitative, manner.

Of those recorded, five of the calves were born in a loose-housed, straw bedded yard (F132, F165, F166, F169, F170). These animals were usually transferred to an individual calving box within a few hours of their birth. On one occasion, the calf (F132) of a heifer was "mothered" i.e. licked, nudged, by an older cow which actively prevented the heifer from licking and nuzzling her calf. The cow achieved this by placing herself between the heifer and the calf and by butting the heifer when she came close. This continued until the heifer and her calf were removed from the group, a period of approximately three hours. This behaviour possibly occurred because the heifer had experienced a difficult calving, (eventually being assisted by the stockman), and remained recumbent for a period of 52 minutes after the birth. In addition, the older cow was showing the initial stages of parturition i.e. restless behaviour and protrudence of the amniotic sac.

After being transferred to an individual calving box, the heifer showed interest in the calf, nosing and licking it, but circled away whenever it attempted to suckle. This was due, in part, to the heifer attempting to continue to lick the calf. The calf was eventually (approx. six hours after birth) held on a teat by the stockman, after which the heifer allowed the calf

to suckle.

The remaining five calves observed were born in the individual calving pens. From these records the median and range of the various activities recorded within the first two hours was calculated. These are given in Table 4.2.1. The data for the calves born in yard are not included here as there were several uncontrollable variables e.g. the presence of other adult cows, which could have influenced their behaviour.

Table 4.2.1.

SUMMARY OF BEHAVIOURAL ACTIVITY OF DAM AND CALF DURING THE FIRST TWO HOURS FOLLOWING PARTURITION.

OBSERVATION	MEDIAN	RANGE
Time taken by cow to stand (mins)	1	0 - 35
Time spent by cow : licking calf	52	21 - 85
(mins) : resting and/or ruminating	35	0 - 60
: other activity (e.g. drinking)	45	0 - 53
Time taken by calf to stand for period > 1 min. (mins)	35	15 - 58
Time taken to first suckling attempt (mins)	78	30 - >120
Time spent by calf : resting	67	55 - 120
(mins) : suckling	5	0 - 11
: other activity (e.g. attempting to stand, walking)	48	0 - 61
Number of attempts to stand before successful	1	0 - 6
Number of attempts to suckle	1	0 - 6

4.3. DEVELOPMENT OF BEHAVIOURAL ACTIVITIES OF THE GROUP

4.3.1. General Development of Behavioural Patterns

This section is basically a descriptive analysis of the data. It attempts to establish the general development of behavioural activities, in terms of proportion of time spent or frequency of occurrence. This is considered in two ways :- 1)The development of behavioural activities of animals of the same chronological age, but possibly within different rearing conditions, and 2)the development of behaviour patterns where the animals have similar periods of experience within particular rearing conditions, but where the ages of the animals varies. Sequences of behavioural activity are used to illustrate the context of the activities.

All the data collected using the focal animal sampling of the individuals is summarised in tables of different ages and in tables of length of time within a particular rearing condition. These record the number of times an animal was observed to perform that activity either when recorded every thirty seconds (for proportion of time spent) or the total occurrences of that behaviour (for frequency per hour).

The development of behaviour patterns of animals of the same chronological age was considered first. From the relevant tables it was possible to determine the development of the ratio of time spent lying to standing and this is shown in Figure 4.3.1. The different rearing conditions experienced by the calves are included on all the graphs with CH - Calf-house, CGI - Weaned calves housed indoors, HG1 - First grazing period of the heifers, HI - Heifers housed indoors and HG2 - Second

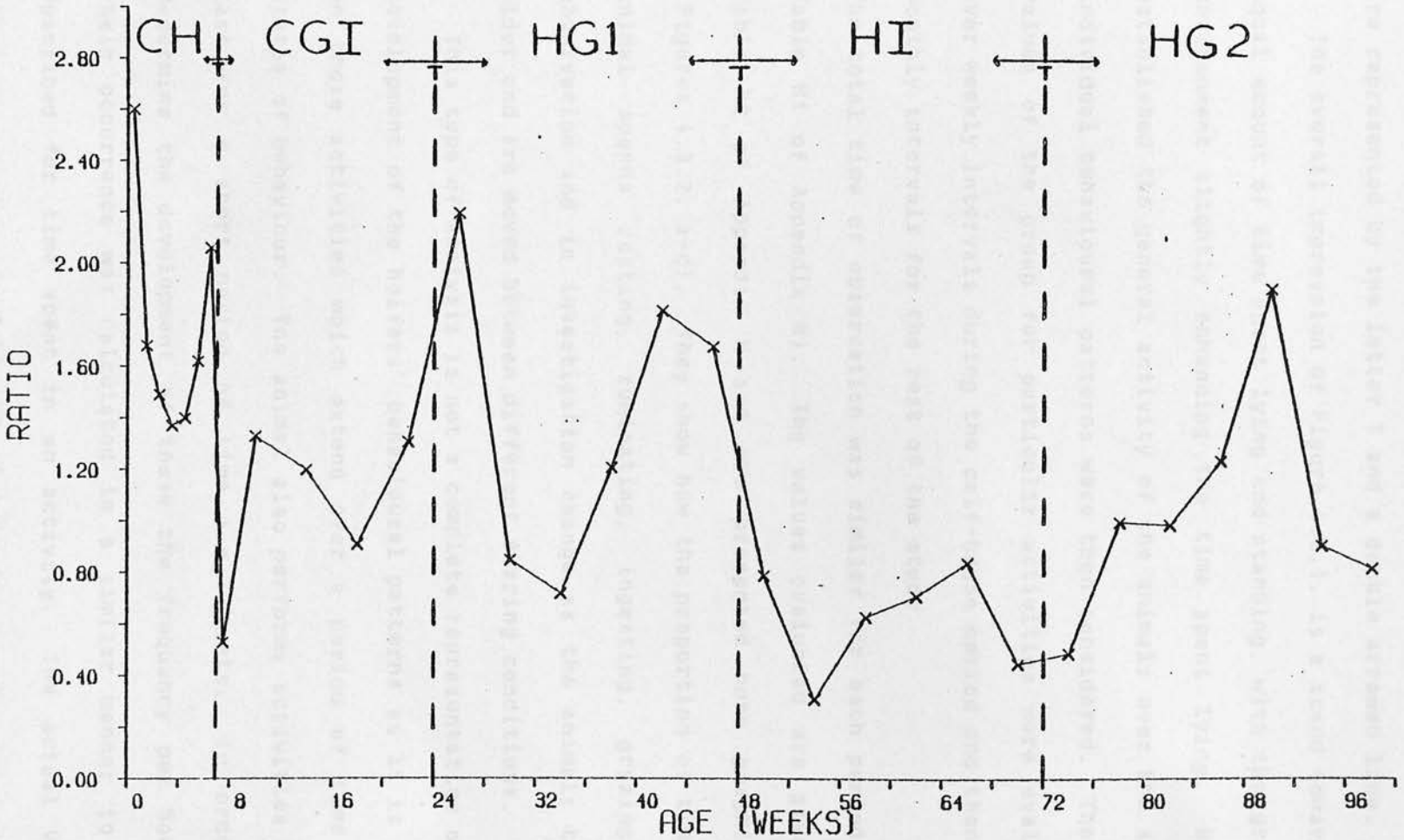


Figure 4.3.1 RATIO OF TIME SPENT IN LYING ACTIVITIES TO STANDING ACTIVITIES

grazing period of the heifers. The period during which the animals were transferred from one rearing condition to the next are represented by the letter T and a double arrowed line.

The overall impression of Figure 4.3.1. is a trend towards an equal amount of time spent lying and standing, with the grazing environment slightly enhancing the time spent lying. Having established the general activity of the animals over the study, individual behavioural patterns were then considered. The mean values of the group for particular activities were evaluated over weekly intervals during the calf-house period and then over monthly intervals for the rest of the study.

The total time of observation was similar for each period (see Table H1 of Appendix H). The values evaluated are given in Table H2 of Appendix H and are presented here graphically (Figures 4.3.2. a-c). They show how the proportion of time the animal spends resting, ruminating, ingesting, grazing, in observation and in investigation change as the animals become older and are moved between different rearing conditions.

This type of analysis is not a complete representation of the development of the heifers' behavioural patterns as it is based on those activities which extend over a period of time i.e. states of behaviour. The animal also performs activities which last for a short period of time i.e. events. In order to determine the development of these the frequency per hour of their occurrence was calculated in a similar manner to that described for time spent in an activity. The actual values obtained are given in Table H3 of Appendix H and presented here

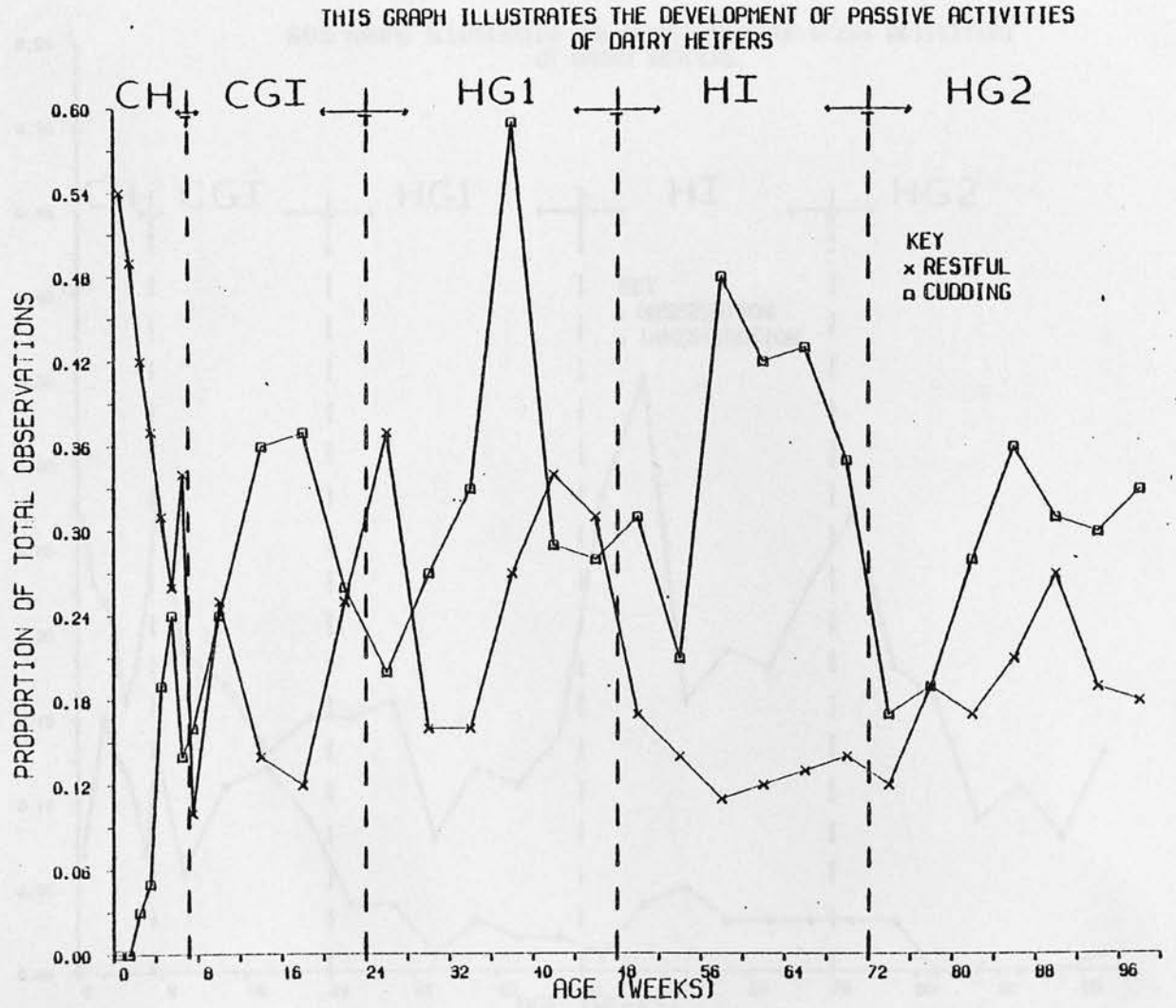


Figure 4.3.2.a) PROPORTION OF TIME SPENT IN CERTAIN BEHAVIOURAL ACTIONS EXPRESSED BY DAIRY HEIFERS

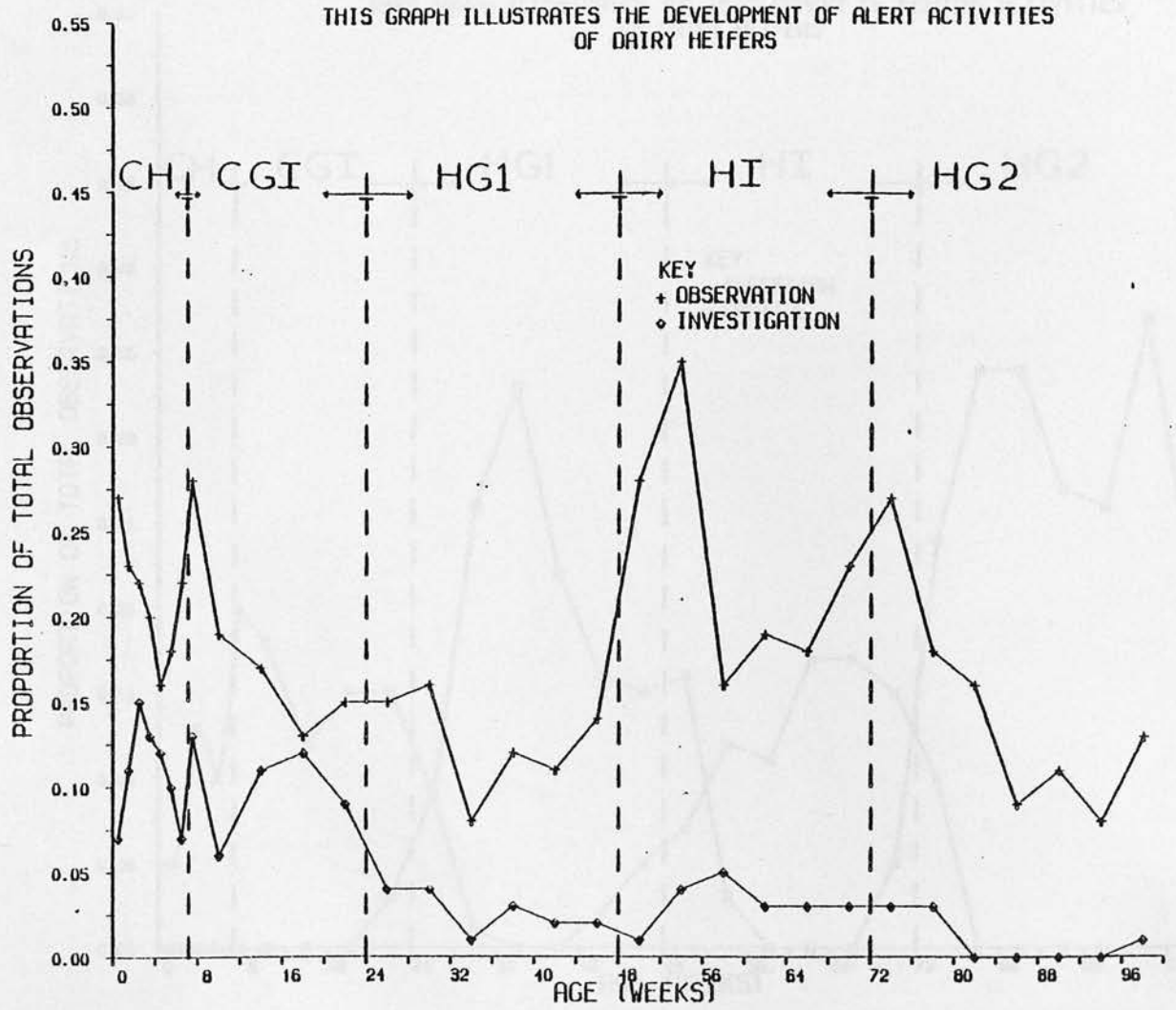


Figure 4.3.2.b) PROPORTION OF TIME SPENT IN CERTAIN BEHAVIOURAL ACTIONS EXPRESSED BY DAIRY HEIFERS

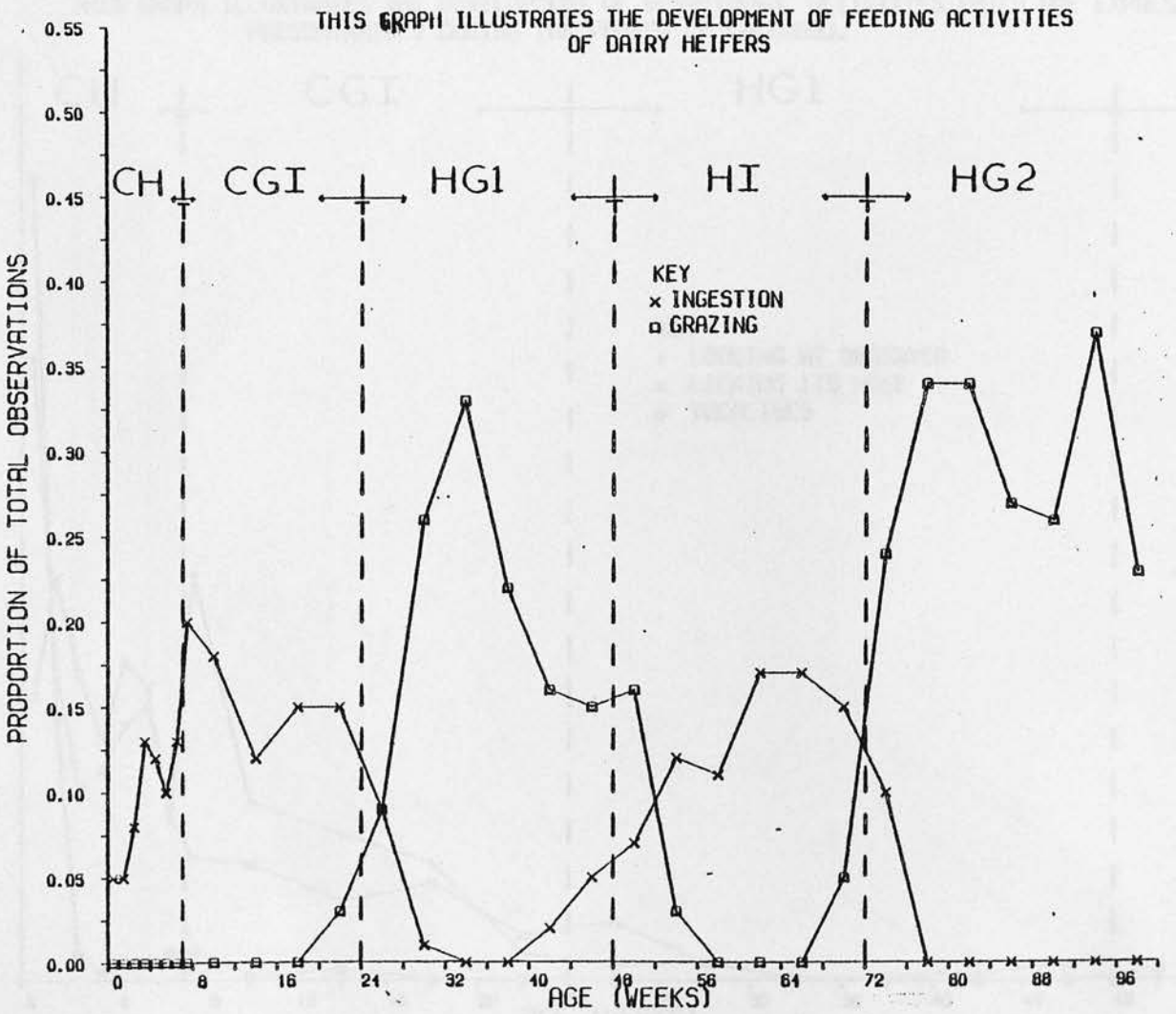


Figure 4.3.2.c) PROPORTION OF TIME SPENT IN CERTAIN BEHAVIOURAL ACTIONS EXPRESSED BY DAIRY HEIFERS

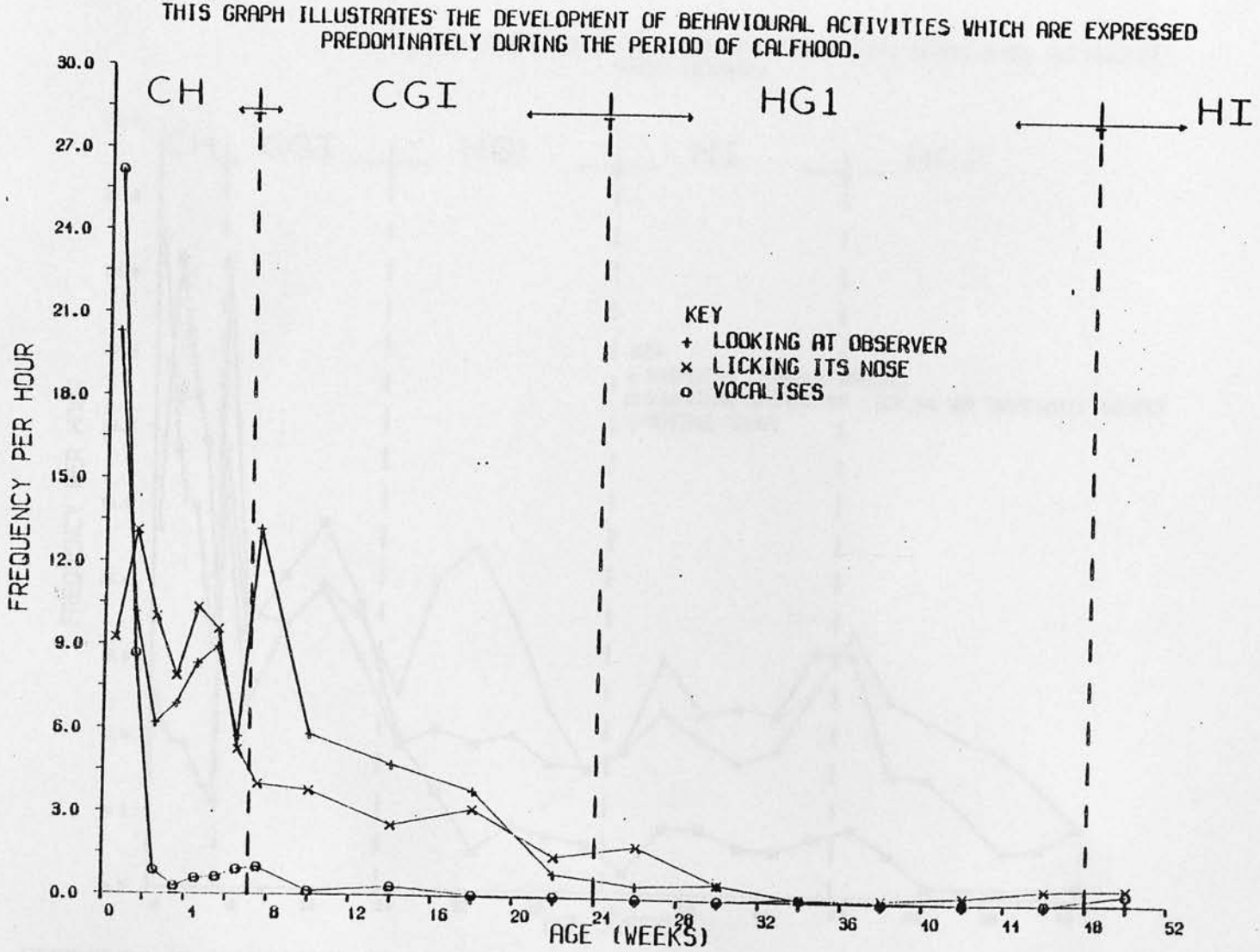


Figure 4.3.3.a) FREQUENCY OF OCCURRENCE OF SOME BEHAVIOURAL ACTIVITIES EXPRESSED BY DAIRY HEIFERS

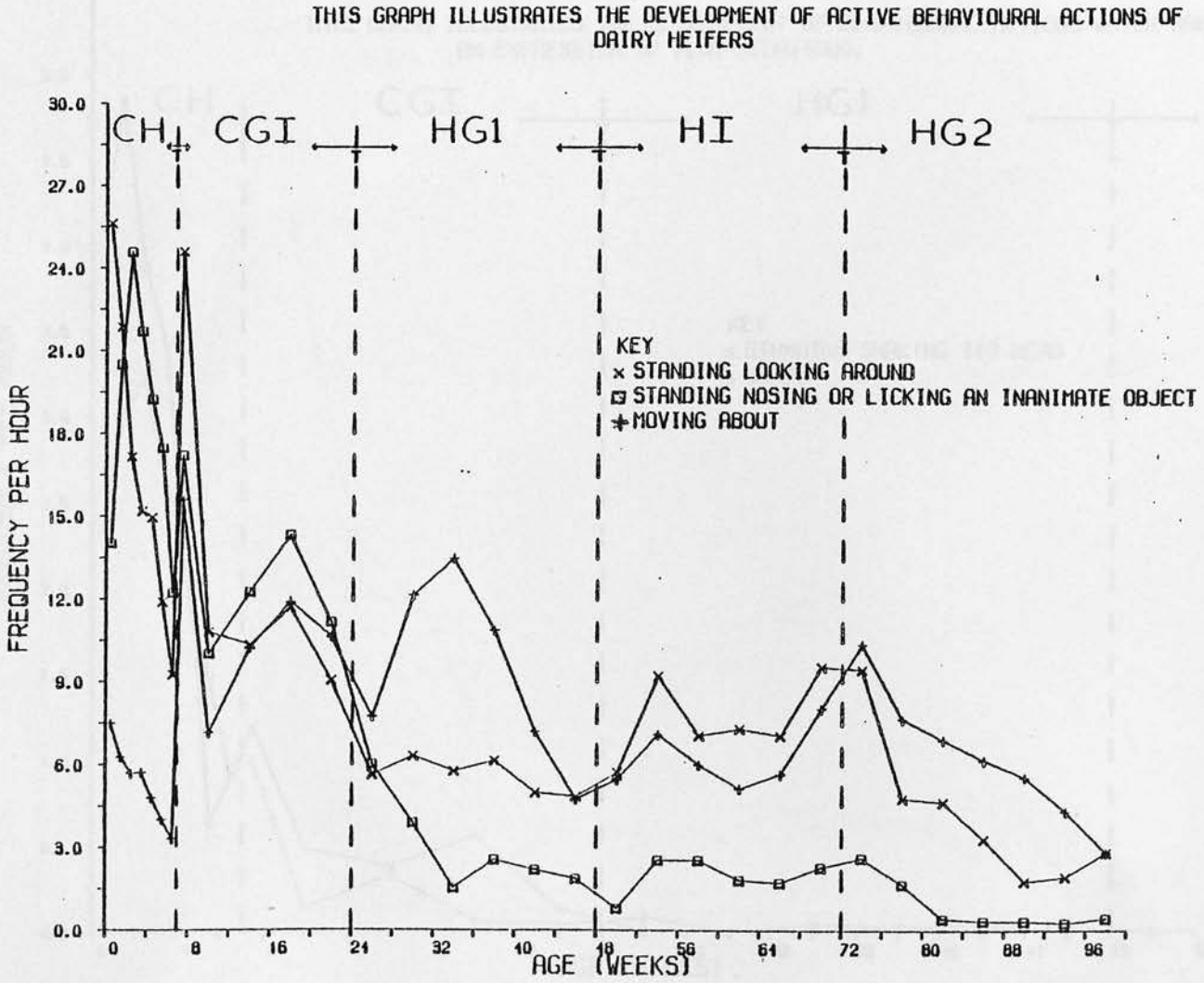


Figure 4.3.3.b) FREQUENCY OF OCCURRENCE OF SOME BEHAVIOURAL ACTIVITIES EXPRESSED BY DAIRY HEIFERS

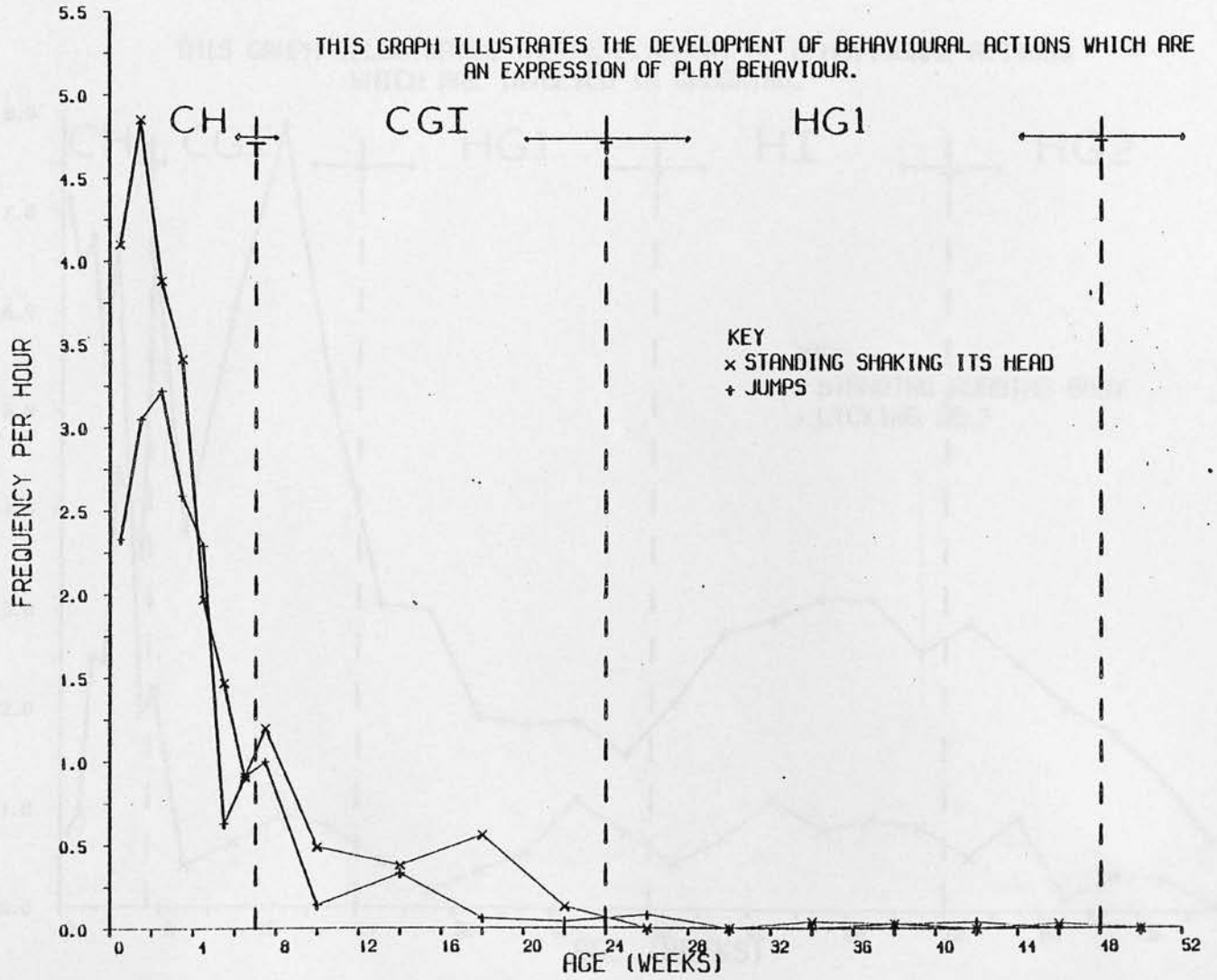
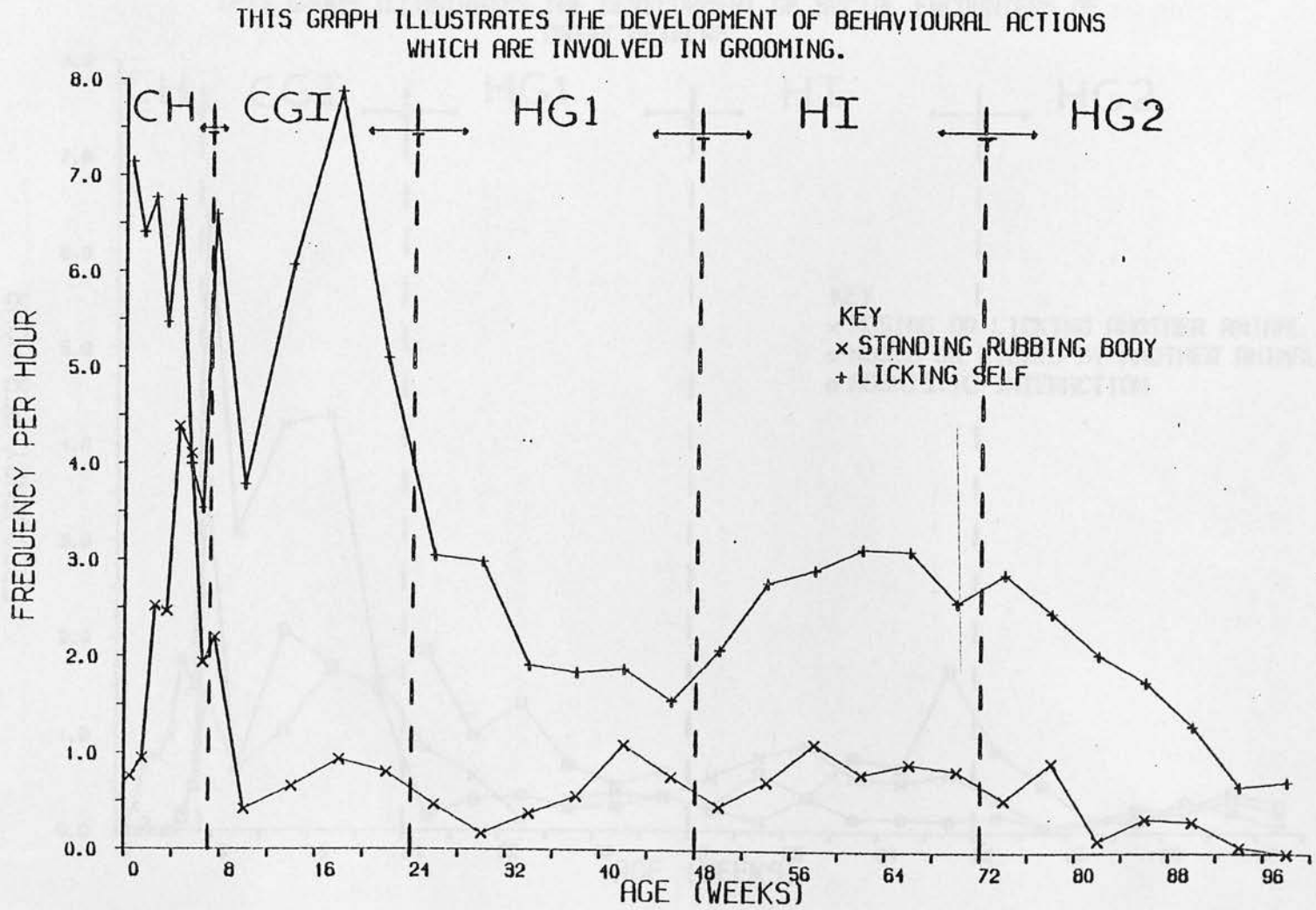


Figure 4.3.3.c) FREQUENCY OF OCCURRENCE OF SOME BEHAVIOURAL ACTIVITIES EXPRESSED BY DAIRY HEIFERS



igure 4.3.3.d) FREQUENCY OF OCCURRENCE OF SOME BEHAVIOURAL ACTIVITIES EXPRESSED BY DAIRY HEIFERS

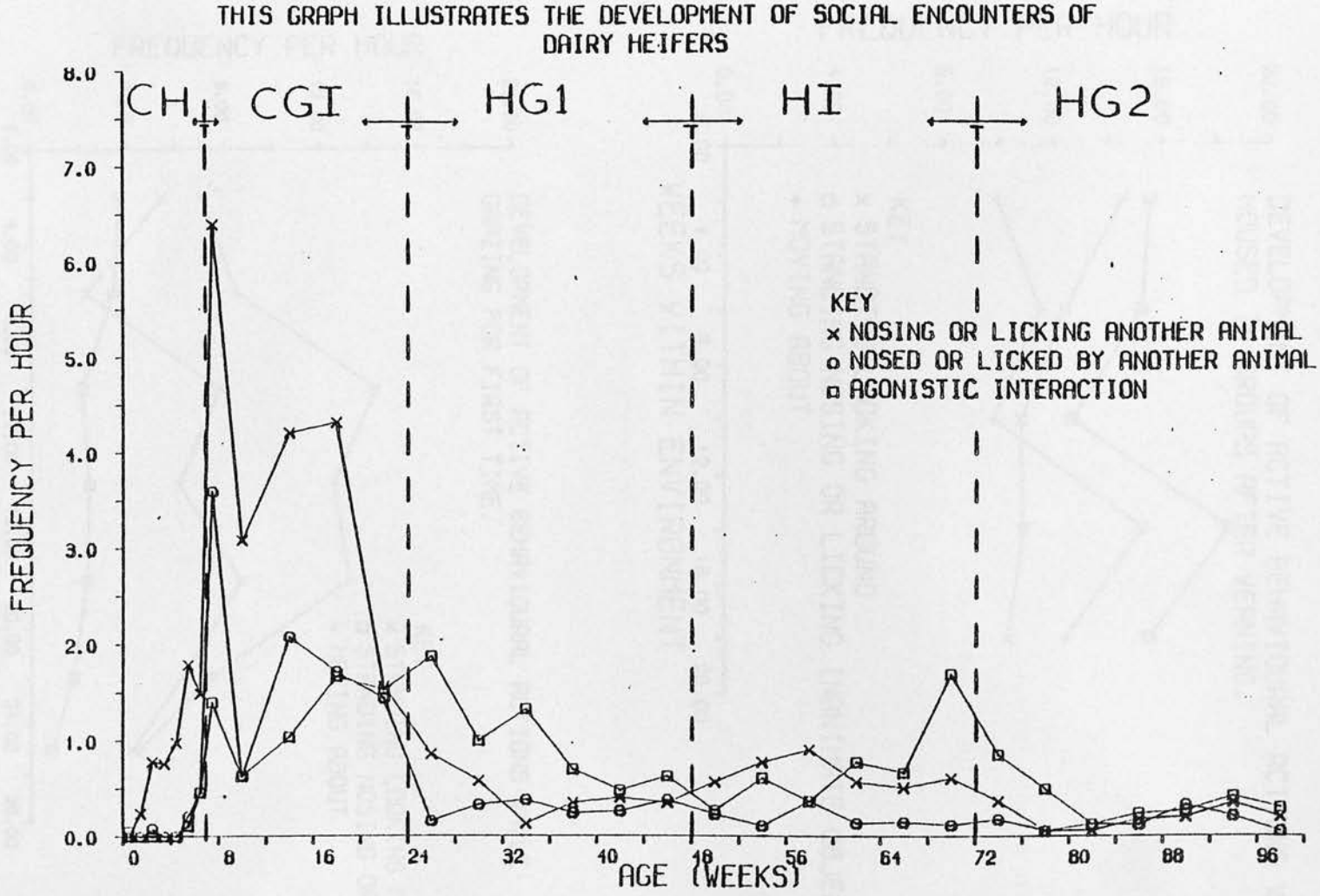
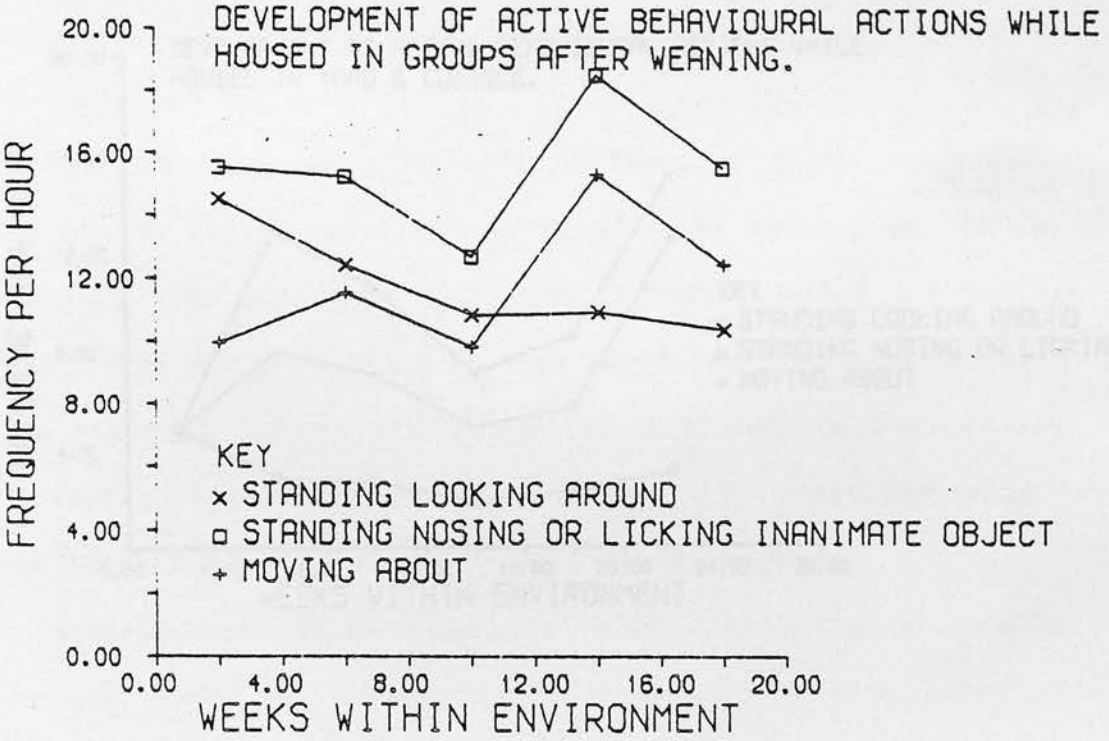


Figure 4.3.3.e) FREQUENCY OF OCCURRENCE OF SOME BEHAVIOURAL ACTIVITIES EXPRESSED BY DAIRY HEIFERS

Figure 4.3.4.
DEVELOPMENT OF SOME BEHAVIOUR PATTERNS OF DAIRY HEIFERS WHILE WITHIN PARTICULAR REARING CONDITIONS.



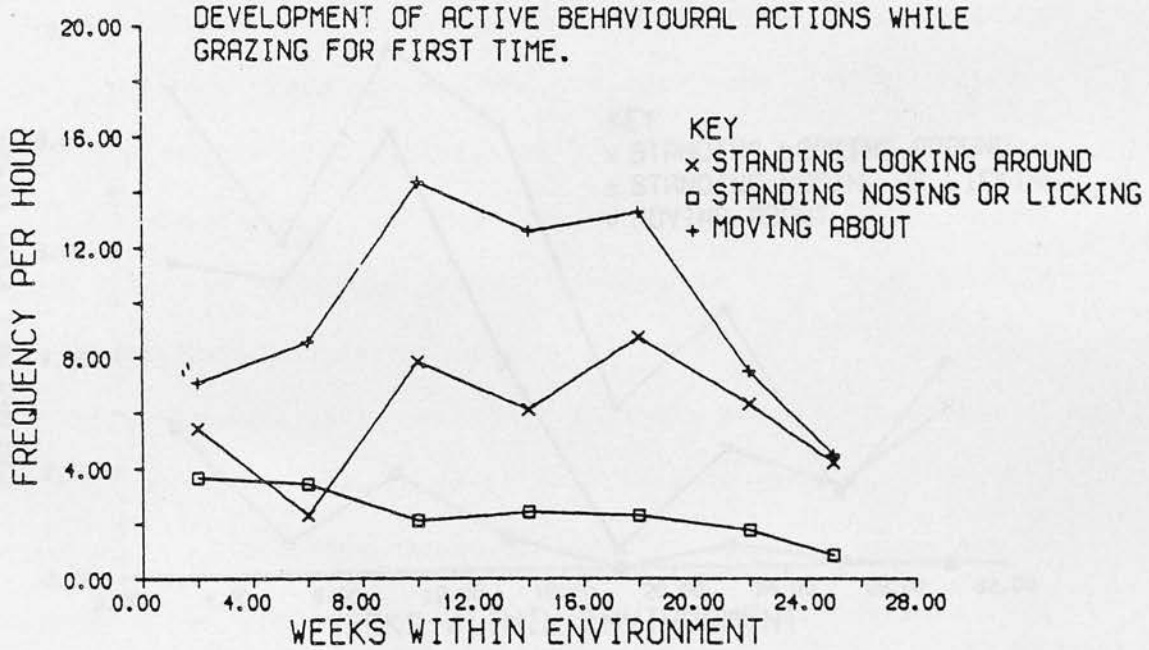
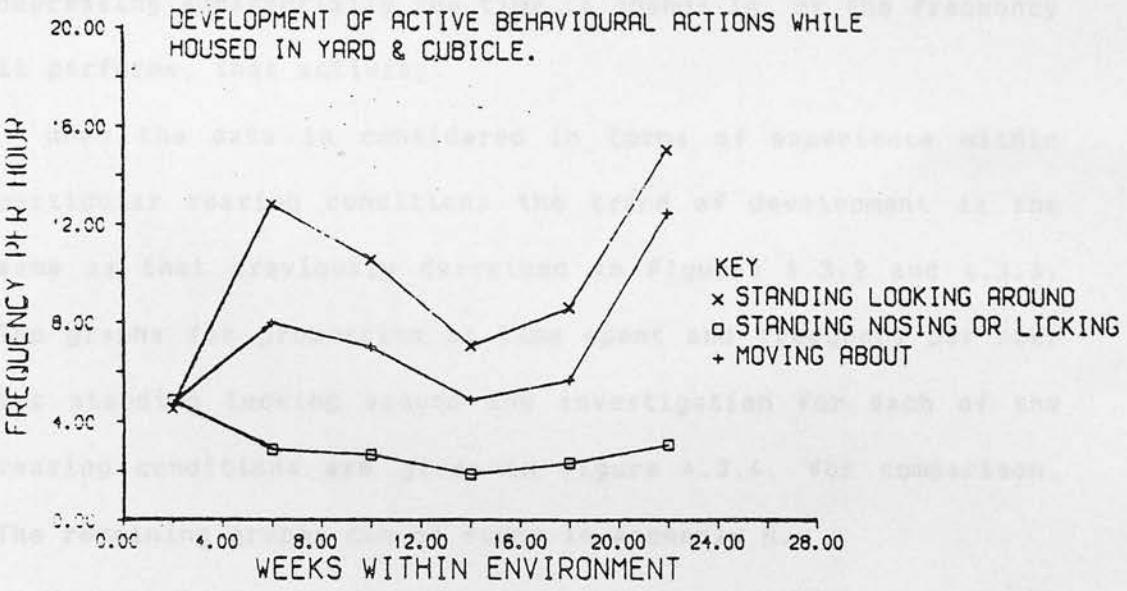
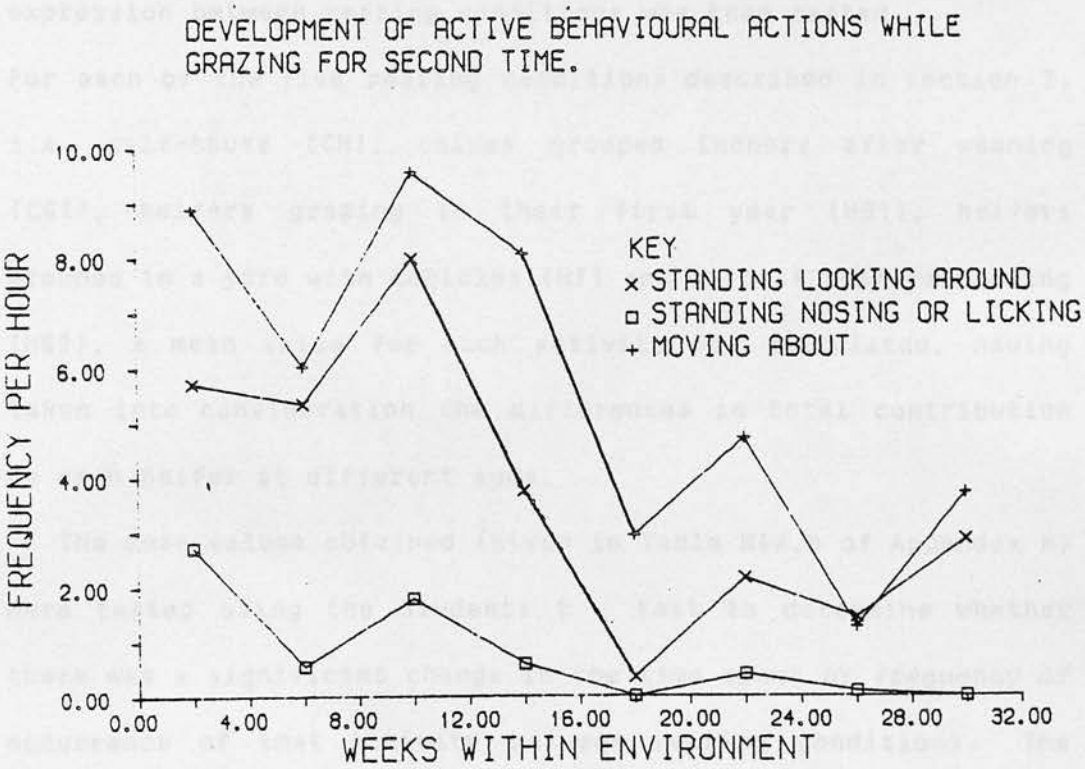


Figure 4.3.4.
DEVELOPMENT OF SOME BEHAVIOUR PATTERNS OF DAIRY HEIFERS WHILE WITHIN PARTICULAR REARING CONDITIONS. (cont.)





in Figures 4.3.3. a-e. Both figures 4.3.2 and 4.3.3 show that transitions from one environment to another affects the expression of behaviour patterns initially, either enhancing or depressing substantially the time it spends in, or the frequency it performs, that activity.

When the data is considered in terms of experience within particular rearing conditions the trend of development is the same as that previously described in Figures 4.3.2 and 4.3.3. The graphs for proportion of time spent and frequency per hour for standing looking around and investigation for each of the rearing conditions are given in Figure 4.3.4. for comparison. The remaining graphs can be found in Appendix H.

Nevertheless, given time the animals attain a reasonably constant level of expression. The change in this level of expression between rearing conditions was then tested.

For each of the five rearing conditions described in section 3, i.e. calf-house (CH), calves grouped indoors after weaning (CGI), heifers grazing in their first year (HG1), heifers grouped in a yard with cubicles (HI) and in-calf heifers grazing (HG2), a mean value for each activity was calculated, having taken into consideration the differences in total contribution by each heifer at different ages.

The mean values obtained (given in Table H4a,b of Appendix H) were tested using the Students t - test to determine whether there was a significant change in the time spent or frequency of occurrence of that activity between rearing conditions. The results shown in Table 4.3.1a,b. indicate that there were

ACTIVITY	COMPARISON BETWEEN MEAN VALUE OF ACTIVITY IN :- CH v CGI t value	CGI v HG1 t-value	HG1 v HI t-value	HI v HG2 t-value	CGI v HI t-value	HG1 v HG2 t-value
Restful	4.525 ***	2.567 *	4.270 ***	5.174 ***	1.320 ns	1.692 ns
Cudding	8.356 ***	0.774 ns	3.359 *	4.999 ***	2.264 *	0.000 ns
Observation	4.565 ***	1.524 ns	6.565 ***	6.316 ***	5.887 ***	1.488 ns
Investigation	0.073 ns	4.497 ***	0.314 ns	3.817 ***	4.418 ***	2.762 **
Eating	4.087 ***	3.652 ***	3.924 ***	8.127 ***	0.067 ns	3.989 ***

* p<0.05
** p<0.01
*** p<0.001

Table 4.3.1(a)
COMPARISON OF MEAN SCORED OCCURRENCE (for time spent)
OF AN ACTIVITY IN A PARTICULAR REARING CONDITION, BUT WHERE THE
ANIMALS ARE OF VARYING AGES.
(Students t-test statistic)

ACTIVITY	COMPARISON BETWEEN MEAN VALUES OF ACTIVITY IN :- CH v CGI t-value	CGI v HG1 t-value	HG1 v HI t-value	HI v HG2 t-value	CGI v HI t-value	HG1 v HG2 t-value
Licking nose	6.048 ***	6.939 ***	1.070 ns	1.074 ns	0.152 ns	1.111 ns
Looking observer	4.040 ***	7.975 ***	2.112 *	1.000 ns	8.064 ***	1.749 ns
Vocalises	4.458 ***	1.025 ns	0.020 ns	0.985 ns	1.000 ns	1.000 ns
Looking around	3.219 **	3.253 **	3.347 **	9.275 ***	1.393 ns	5.318 ***
Movement	3.428 **	1.556 ns	6.410 ***	0.274 ns	2.934 **	6.901 ***
Investigation	2.699 *	7.717 ***	0.937 ns	5.611 ***	7.729 ***	7.557 ***
Shaking	5.152 ***	5.266 ***	0.592 ns	0.066 ns	5.294 ***	0.642 ns
Jump	3.726 ***	2.176 *	1.875 ns	0.000 ns	2.302 *	0.000 ns
Rubbing	5.022 ***	0.741 ns	2.170 *	4.473 ***	2.055 *	2.340 *
Licking self	0.226 ns	6.768 ***	3.117 **	4.625 ***	4.895 ***	1.390 ns
Nose/lick calf	---------	6.768 ***	2.312 *	1.000 ns	5.090 ***	1.812 ns
N/Li by calf	---------	3.429 **	1.238 ns	0.726 ns	6.380 ***	1.468 ns
Agonistic initiate	-------	0.316 ns	1.953 ns	1.803 ns	1.614 ns	3.350 **
Agonistic recieve	-------	1.238 ns	0.010 ns	1.958 ns	1.230 ns	1.826 ns

* p<0.05
** p<0.01
*** p<0.001

Table 4.3.1(b) COMPARISON OF THE MEAN VALUES OF FREQUENCY OF OCCURRENCE OF ACTIVITIES BETWEEN SUCCESSIVE REARING CONDITIONS
(Students t-test statistic)

significant changes in the mean values, but it is not possible to establish categorically to what degree the different environments affect the development of the behaviour patterns as the normal development in a constant environment is not known.

In summary, the mean time spent resting decreased when the animals were grouped indoors and increased when they were grazing. The average time spent in observation and the frequency of occurrence, decreased when the calves were grouped initially and when grazing for the second time. Both activities increased when the animals were brought into the yard at one year of age. The mean time spent cudding and eating increased after grouping, possibly due partly to social facilitation. The time spent eating decreased when the heifers were housed in the yard, probably due to the more nutritious food source. The time spent cudding generally increased over the first twenty weeks to a level which appears to be maintained thereafter, increasing slightly during yarding and decreasing when returned to grazing. The time spent in investigation was at a peak at about three weeks of age, but the frequency of occurrence was low. This suggests that investigation during the calf-house period was generally of long duration and undisturbed. However, the frequency of occurrence was at a peak when the calves were grouped suggesting that investigation was disrupted more often during this period.

The frequency of those activities exhibited predominately during calf-hood, licking its nose (associated with bucket feeding), looking at the observer (associated with feeding by stockman),

vocalisation and behaviour related to play decreased or disappeared over the first year of the study. Grooming generally decreased in frequency over the study, but did increase when the heifers were grouped in the yard, possibly due to an increase in "spare" time. Movement increased in frequency upon grouping after the calf-house and decreased when they were brought indoors from grazing. Social encounters tended to decrease with age, apart from an increase in social licking when the heifers were brought into the yard.

The first recorded expression of a behavioural activity by the dairy calves in this study and by the field calves reported in the study by Wood-Gush et al 1984, is summarised in Table 4.3.2.

Table 4.3.2.
AGE OF FIRST OBSERVATION OF BEHAVIOURAL ACTIVITIES OF CALVES.

BEHAVIOURAL ACTIVITY	AGE OF CALF WHEN ACTIVITY FIRST OBSERVED (Weeks) Dairy	Field
Lying asleep or resting	< 1 wk	< 1 wk
Observation	< 1 wk	
Ingestion of solid food (or grazing)	< 1 wk	1 - 2 wk
Rumination	2 - 3 wk	1 - 2 wk
Vocalisation	< 1 wk	
Nosing an object	< 1 wk	< 1 wk
Licking an object	< 1 wk	
Licking its body (grooming)	< 1 wk	< 1 wk
Licking its nose	< 1 wk	
Hind leg scratch	2 - 3 wk	< 1 wk
Rubbing its body against object	< 1 wk	
Shaking head or body	< 1 wk	
Jump	< 1 wk	
Nosing or licking a calf	2 - 3 wk	< 1 wk
Agonistic interaction	5 - 6 wk	
Run	6 - 7 wk	
Mount	8 - 9 wk	
Play		2 - 3 wk

This shows that the calves perform most of the behaviour patterns expressed by adult animals at an early age. However, few are expressed at the same level (proportion of time, or frequency) as the mature animals. Also, several activities are not performed in relation to the same stimuli as older animals. For example, run, mount and butting are expressed during play bouts by calves but are expressed in different situations by older animals. Although there are differences between the dairy and field calves, complete comparison is not possible due to the dairy calves being restricted in their opportunities for interaction with others as they were individually penned for the first 6-8 weeks.

4.3.2. Development of Behavioural Sequences

In order to determine the relative context of the activities recorded, analysis of the sequences of behavioural activities is necessary. Using a modified version of a program written by Dr. R. Hutton, the data was analysed in a first-order transition matrix. That is, the change from one behavioural activity (termed precede co-ordinate) to the next activity (termed follow co-ordinate) was incremented in a matrix, with the follow co-ordinate becoming the next precede co-ordinate of the matrix repeated until the end of the sequence is reached. An example of the resulting matrix is given in Appendix I. The Chi-square test statistic was then used to examine whether any transitions occurred more often than expected by chance. An Imp program, provided by Dr. J. Deag in the Dept. of Zoology (based on a

program by Reuchten & Fernald 1979), evaluated the expected values for the matrix with the diagonal being zero as no activity was expected to follow itself. The table was then collapsed into a single-cell contingency table to test the specific transitions which had expected values greater than five. For example, examination of the transition Standing looking around (SLA) to Standing nosing (SN) would result in the calculation shown in Figure 4.3.5.

Figure 4.3.5.

AN EXAMPLE OF THE DETERMINATION OF A SIGNIFICANT TRANSITION

AGE = 1 WEEK

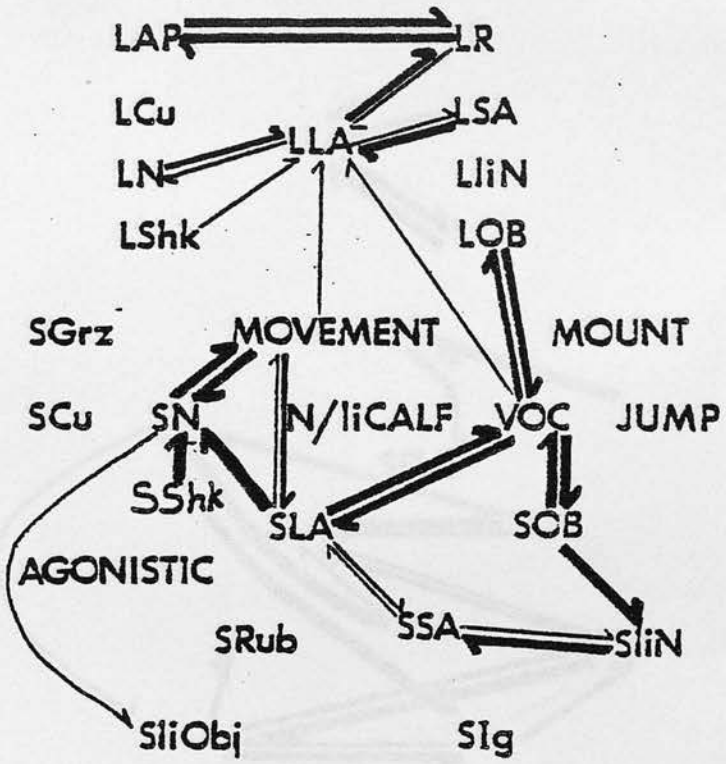
MEASUREMENT	TRANSITION		TOTAL
	SLA-->SN	SLA-->OTHERS	
OBSERVED VALUE (from matrix)	75	427	502
EXPECTED VALUE (from matrix)	47.4	454.6	502

χ^2 (with 1d.f.) = 17.747 --- significant at $p<.001$

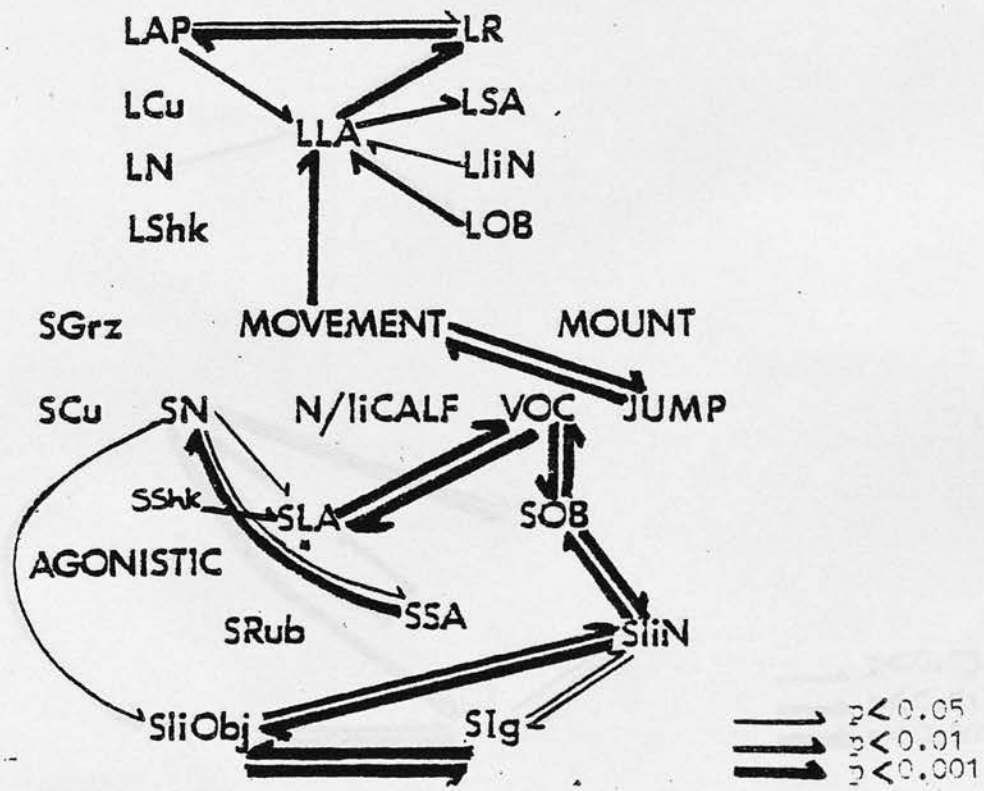
The transitions which occurred significantly more often than expected by chance (i.e. significant Chi-square test statistic value) were then illustrated on diagrams of behavioural activities to show siginificant associations between activities at different ages. Appendix I contains the diagrams for each month of age of the group. The data for separate rearing conditions, apart from the calf-house, is grouped together to provide a single diagram showing the significant associations of

Figure 4.3.6.

SIGNIFICANT TRANSITIONS BETWEEN BEHAVIOURAL ACTIVITIES AT VARIOUS AGES



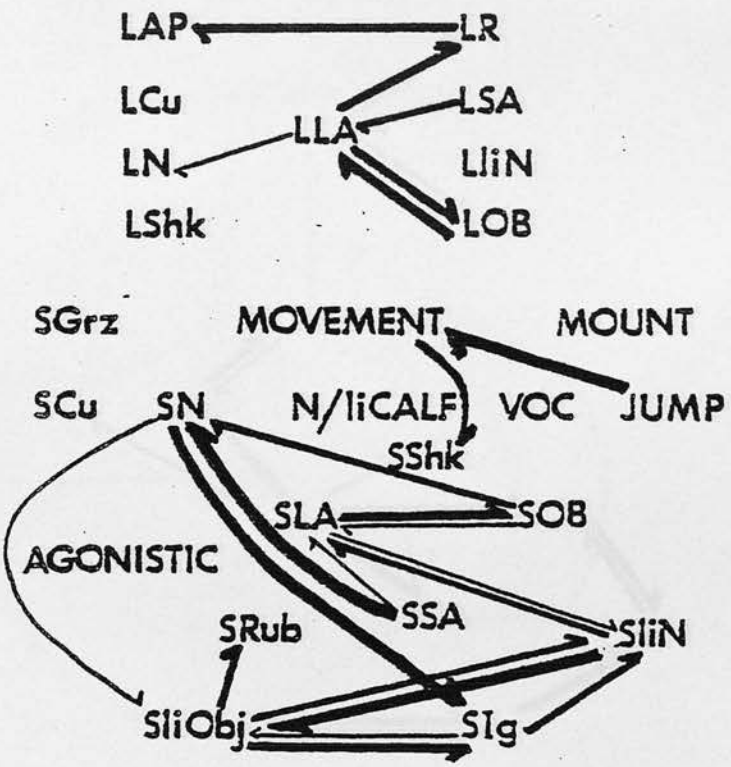
a) AGE = 1 WEEK (CH)



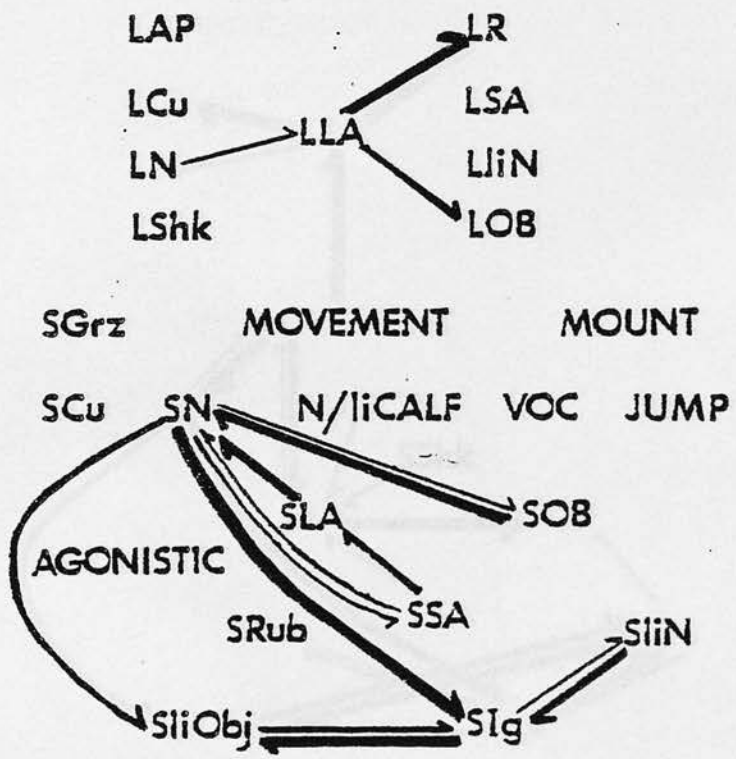
b) AGE = 2 WEEKS (CH)

Figure 4.3.6. (cont.)

SIGNIFICANT TRANSITIONS BETWEEN BEHAVIOURAL ACTIVITIES AT VARIOUS AGES



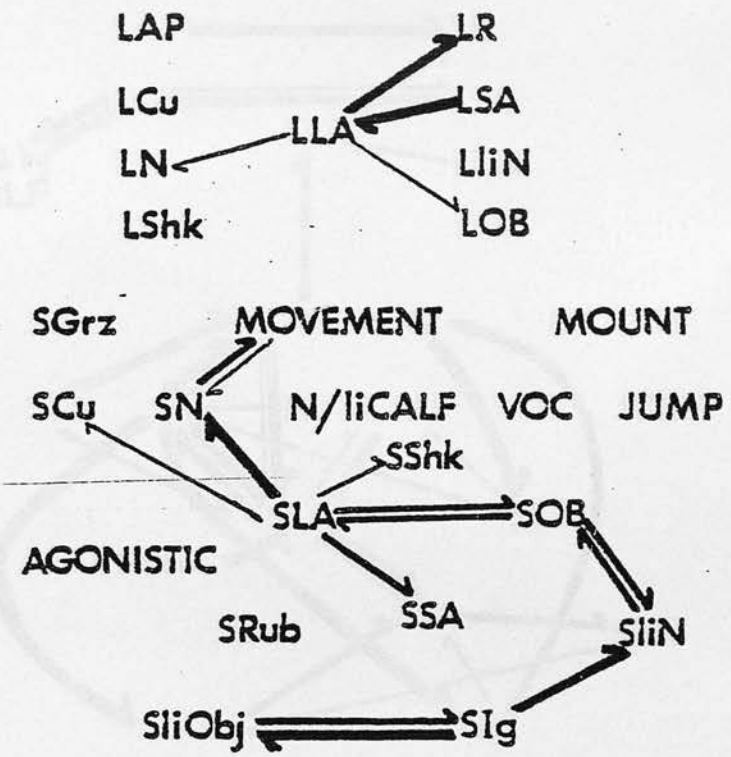
c) AGE = 3 WEEKS (CH)



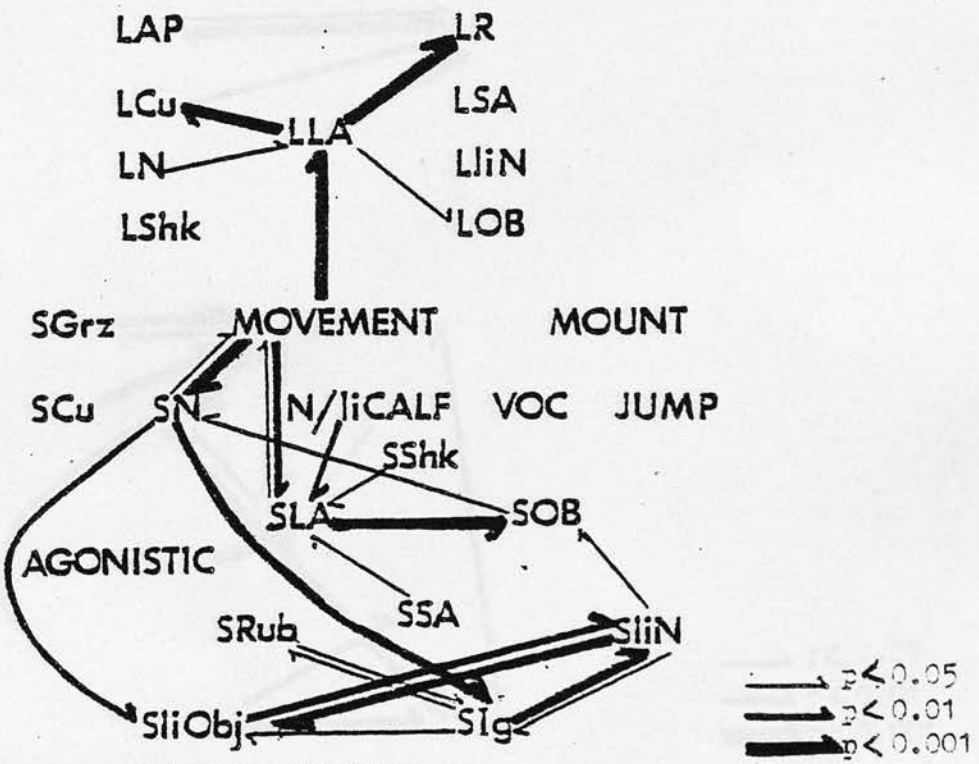
d) AGE = 4 WEEKS (CH)

Figure 4.3.6. (cont.)

SIGNIFICANT TRANSITIONS BETWEEN BEHAVICURAL ACTIVITIES AT VARIOUS AGES



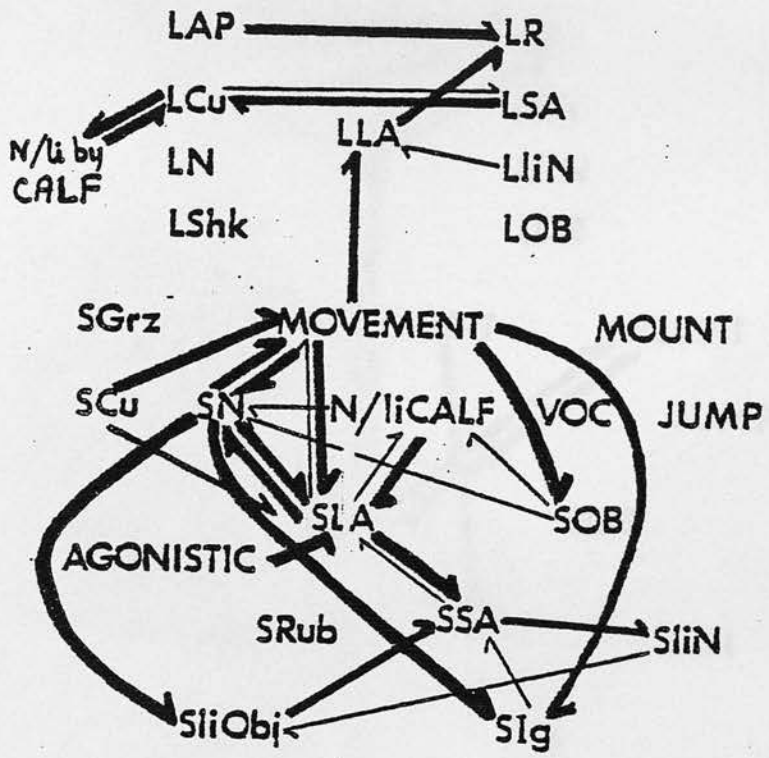
e) AGE = 5 WEEKS (CH)



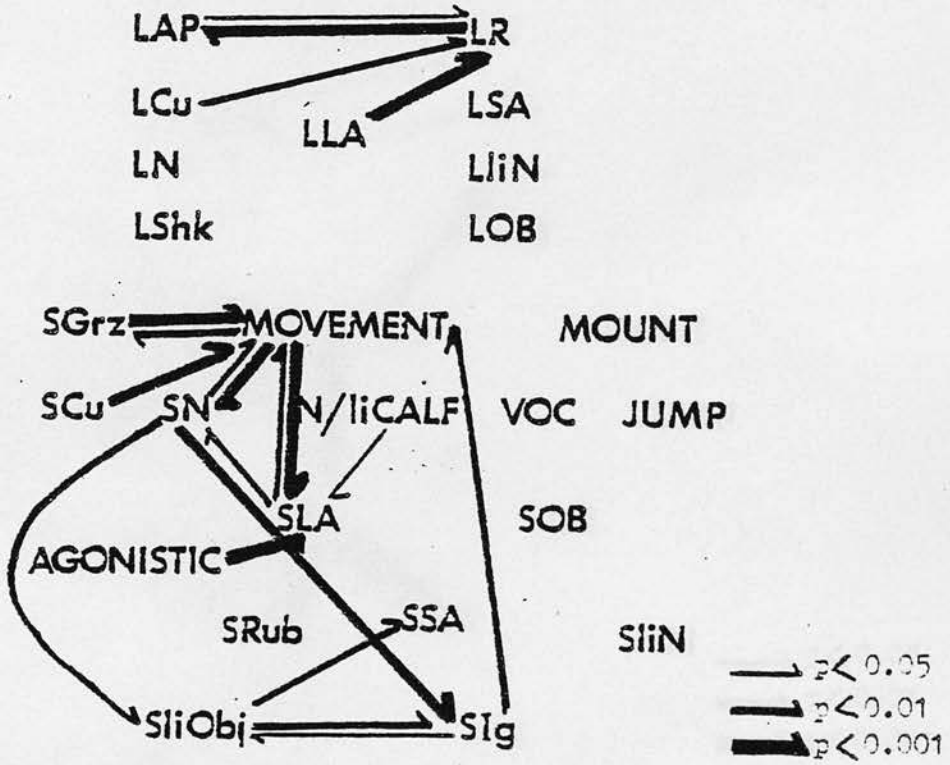
f) AGE = 6-8 WEEKS (TRANS CH→CGI)

Figure 4.3.6. (cont.)

SIGNIFICANT TRANSITIONS BETWEEN BEHAVIOURAL ACTIVITIES AT VARIOUS AGES



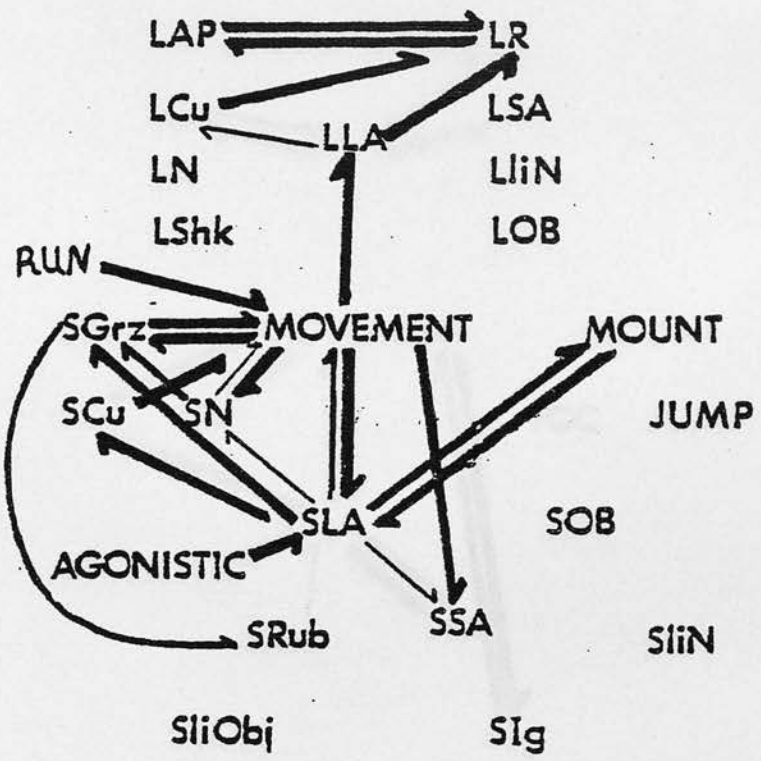
g) AGE = 3-5 MONTHS (CGI)



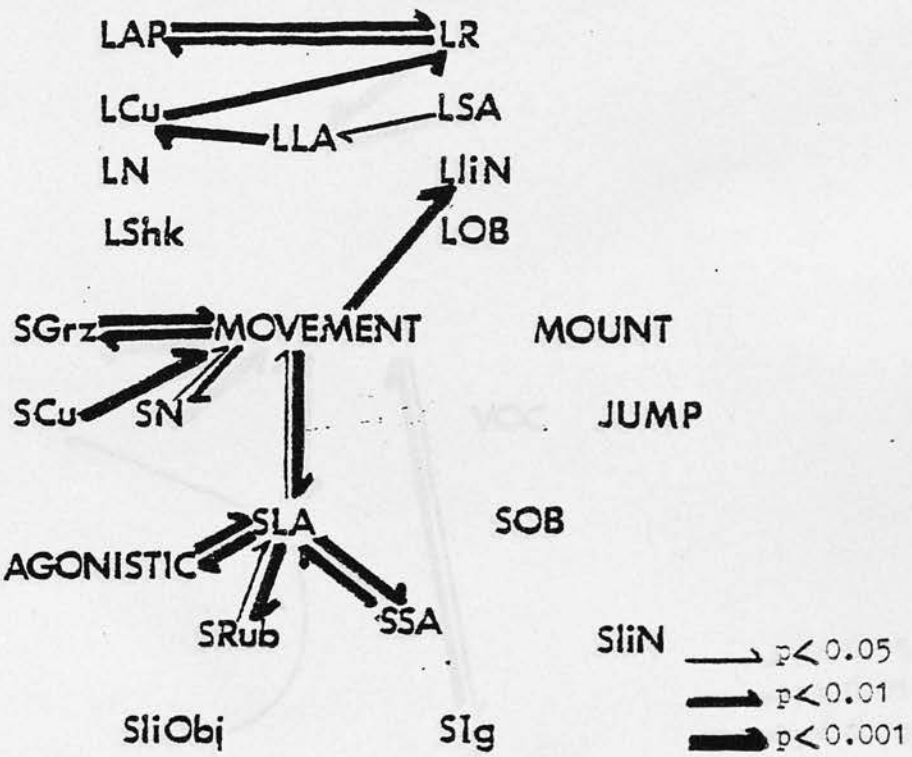
h) AGE = 6-7 MONTHS (TRANS CGI→HG1)

Figure 4.3.6. (cont.)

SIGNIFICANT TRANSITIONS BETWEEN BEHAVIOURAL ACTIVITIES AT VARIOUS AGES



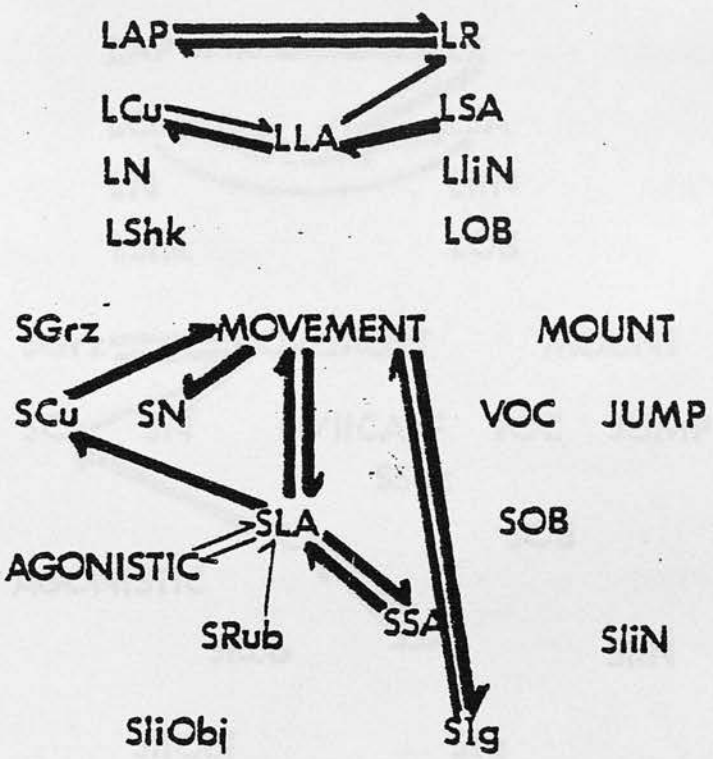
i) AGE = 8-11 MONTHS (HG1)



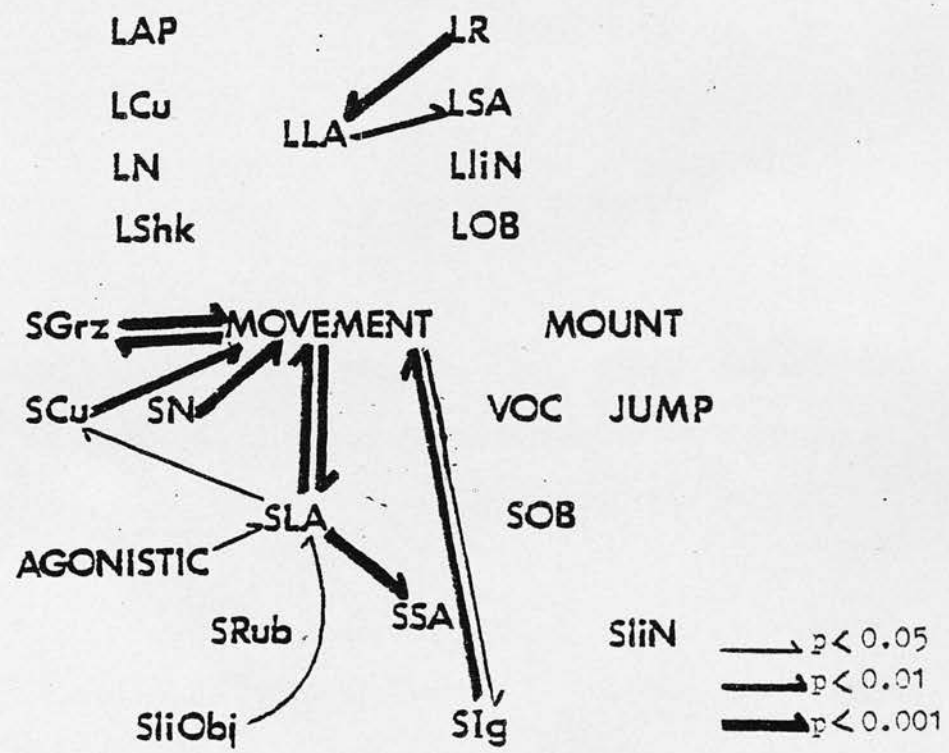
j) AGE = 12-13 MONTHS (TRANS HG1→HI)

Figure 4.3.6. (cont.)

SIGNIFICANT TRANSITIONS BETWEEN BEHAVIOURAL ACTIVITIES AT VARIOUS AGES



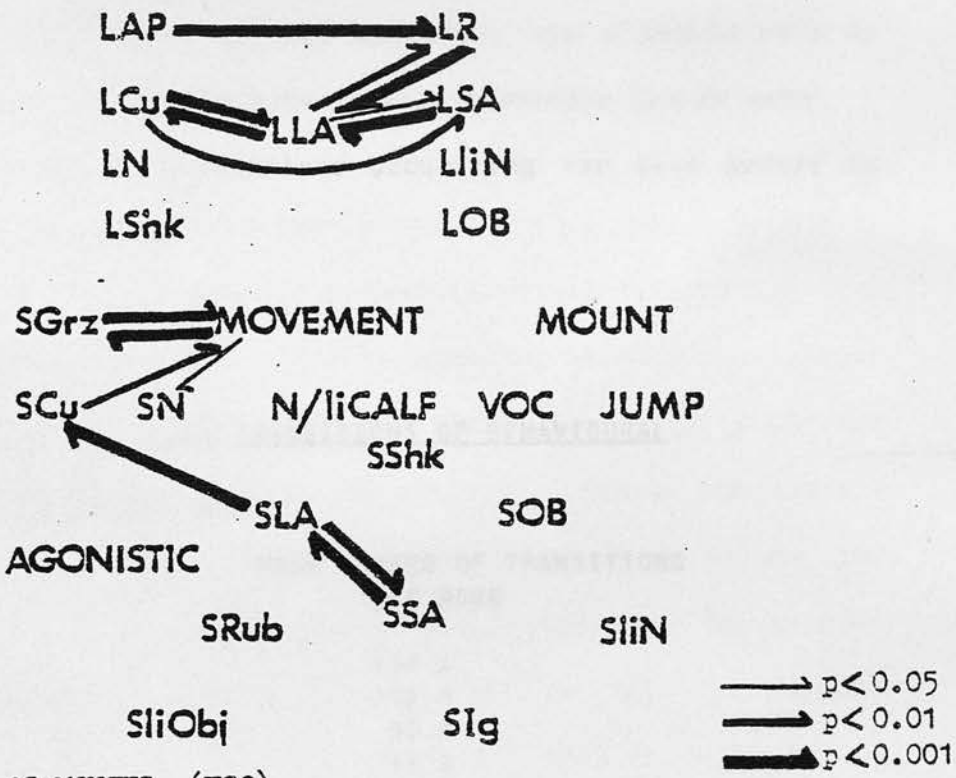
k) AGE = 14-17 MONTHS (HI)



l) AGE = 18-19 MONTHS (TRANS HI→HG2)

Figure 4.3.6. (cont.)

SIGNIFICANT TRANSITIONS BETWEEN BEHAVIOURAL ACTIVITIES AT VARIOUS AGES



j) AGE = 20-25 MONTHS (HG2)

activities in any behavioural sequence observed in that rearing condition. These are shown in Figures 4.3.6. a-m where the change in the context of the activity, its disappearance or emergence in the animal's behavioural repertoire can be seen. The mean number of transitions occurrring for each period is shown in Table 4.3.3.

Table 4.3.3.

MEAN NUMBER OF 1ST ORDER TRANSITIONS OF BEHAVIOURAL ACTIVITIES AT VARIOUS AGES.

AGE	MEAN NUMBER OF TRANSITIONS PER HOUR
1 WEEK	138.4
2 WEEKS	112.1
3 WEEKS	96.9
4 WEEKS	91.3
5 WEEKS	96.2
6--8 WEEKS (C)	84.4
3--5 MONTHS	70.4
6--7 MONTHS(C)	52.5
8-11 MONTHS	38.7
12-13 MONTHS(C)	24.1
14-17 MONTHS	27.6
18-19 MONTHS(C)	32.6
20-25 MONTHS	22.1

(C) - Change over period from one type of housing system to another.

These are obtained by dividing the total number of transitions of behavioural activities recorded in that period by the total number of hours of observation during that period.

Throughout the heifers development, lying looking around (LLA) is the central activity when the animal is lying down. Up to approximately five weeks of age it is basically associated with resting (LAP,LR), after which it is also associated with rumination (LCu), especially at later ages. During the first few weeks of age, vocalisation (VOC) is a central activity to the calves and it is especially associated with observation and people, shown by its connection to standing looking at observer (SOB). Investigation (SN, SLiObject) and observation (SLA) are also becoming central points of activity. These are closely associated with each other, but are also focal points for transition to another activity. After grouping of the calves, following weaning, movement is a central activity and usually leads to investigation or observation and from these to eating and grooming. After turnout to grazing, investigation is no longer a central activity, instead movement and observation are the activities associated in any transitions involving grazing, investigation, rumination, grooming or mounting. When grouped indoors it is basically the same, but with ingestion of silage replacing grazing. In the second grazing period, movement generally leads to grazing, with observation leading to rumination and grooming.

Further, when the mean number of transitions per hour of observation is examined (see Table 4.3.3.) it can be seen that fewer transitions are occurring as the animal matures. This would suggest that as the animal matures fewer behavioural activities are associated in any sequence, and that these show

an increase in their degree of association.

The results obtained in this section are now compared with those obtained from a study of beef calves reared with their dams in semi-natural conditions.

4.3.3. Development of behaviour patterns in calves reared with their dams in extensive conditions

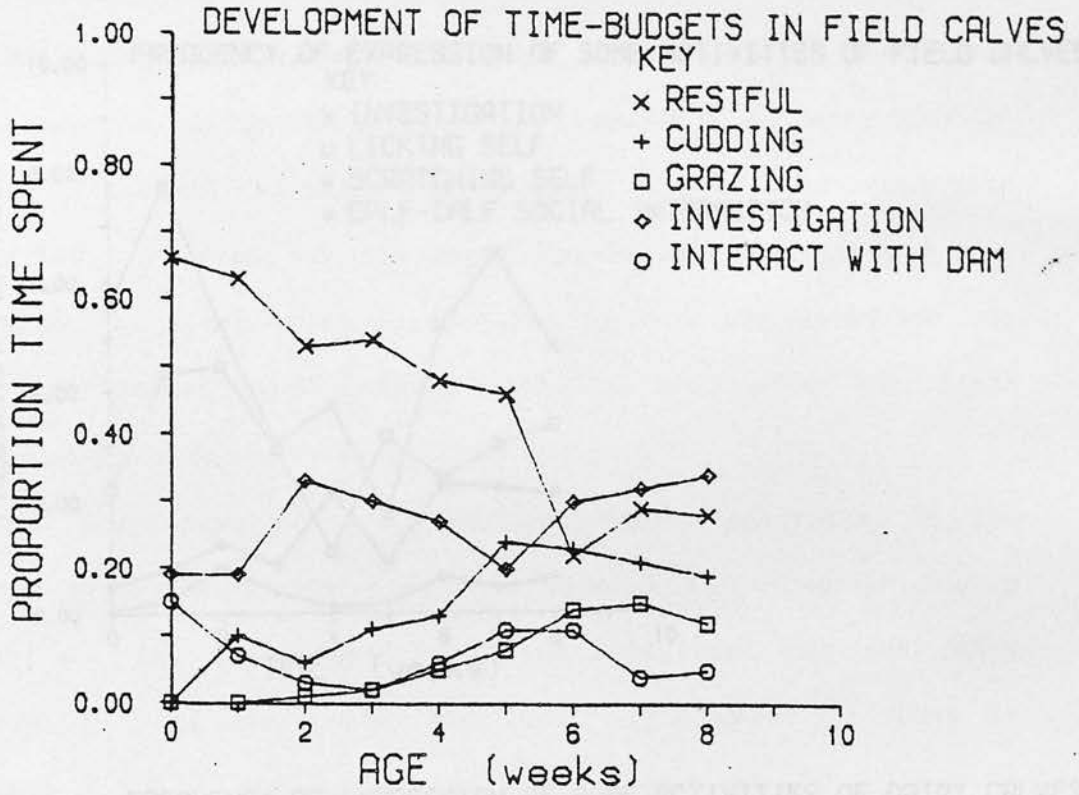
The information contained in this section is presented for comparison of the development of behaviour of calves reared intensively (dairy calves) with that of calves reared in extensive systems (field calves).*

To summarise the data collection and analysis, eight Angus cross calves were observed from birth for a period of nine weeks. During this period scans recording the position and general activity of the calves was recorded every ten minutes and thirty minute focal animal samples recorded all the behavioural activity of each animal. The study used an ethogram similar to that described in section 3.1. The main differences between the ethograms are the inclusion of nursing activities and interactions with adult cows in the field calves study.

*NOTE - Author was part of a team involved in the analysis of data collected on field calves reared with their dams. A full description of materials and methods, together with the results and a general discussion of their development of behaviour in field calves can be found in the paper - "The early behaviour of suckler calves in the field" - D.G.M. Wood-Gush, K. Hunt, Katherine Carson & Sheila G.C. Dennison published in Biology of Behaviour 1984, vol 9 pgs 295-306. A copy of this paper can be found in Appendix M.

Figure 4.3.7.
EARLY DEVELOPMENT OF TIME BUDGETS IN FIELD AND DAIRY CALVES.

a)



b)

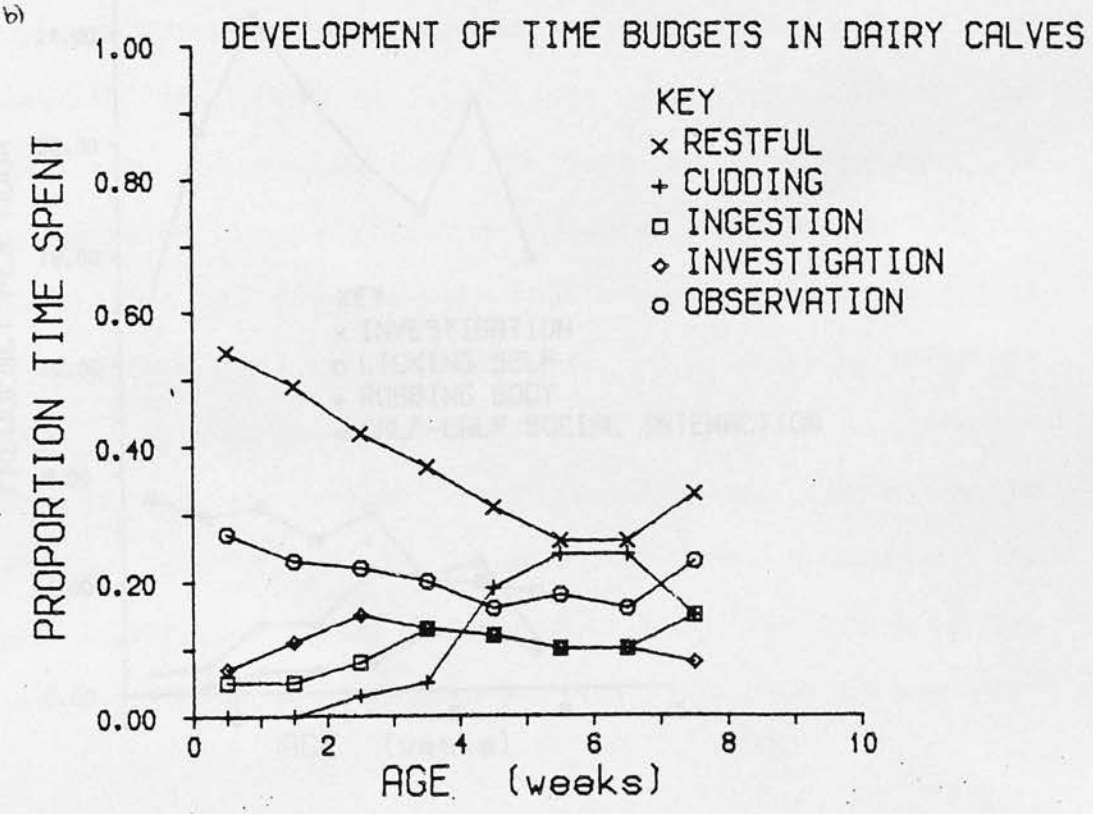
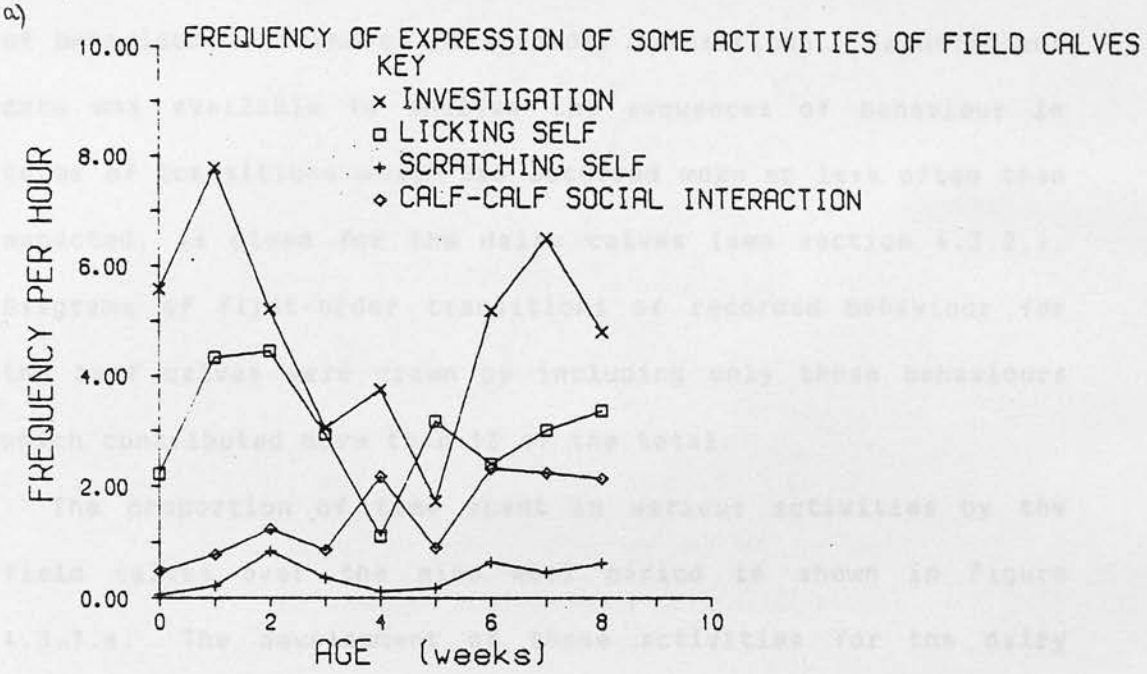
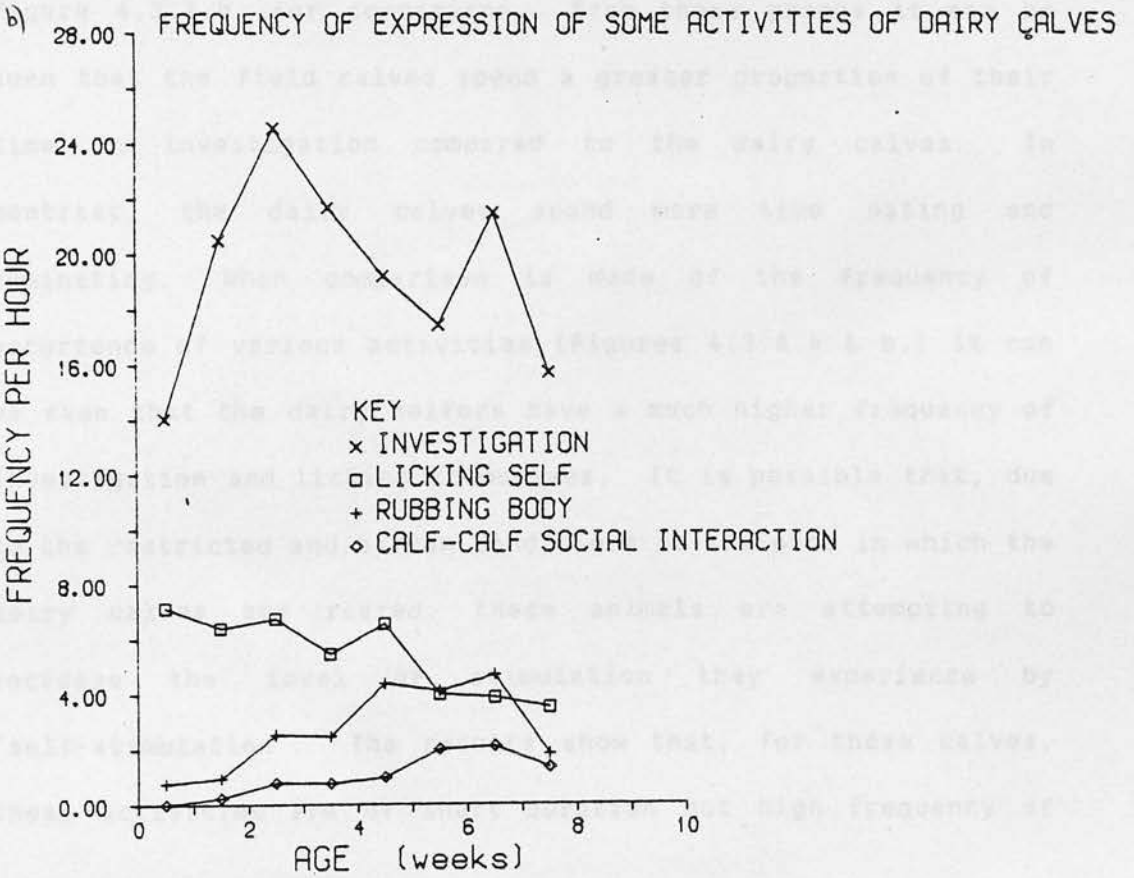


Figure 4.3.8.
EARLY DEVELOPMENT OF FREQUENCY OF OCCURRENCE OF SOME ACTIVITIES BY FIELD AND DAIRY CALVES.

a)



b)



The data collected from the scan samples was analysed to evaluate time-budgets for the calves and the data recorded during the focal animal samples was used to describe sequences of behaviour in terms of first-order transitions. Insufficient data was available to analyse the sequences of behaviour in terms of transitions which had occurred more or less often than expected, as given for the dairy calves (see section 4.3.2.). Diagrams of first-order transitions of recorded behaviour for the beef calves were drawn by including only those behaviours which contributed more than 1% of the total.

The proportion of time spent in various activities by the field calves over the nine week period is shown in Figure 4.3.7.a. The development of these activities for the dairy calves in this study over the first eight weeks is shown in Figure 4.3.7.b. for comparison. From these graphs it can be seen that the field calves spend a greater proportion of their time in investigation compared to the dairy calves. In contrast, the dairy calves spend more time eating and ruminating. When comparison is made of the frequency of occurrence of various activities (Figures 4.3.8.a & b.) it can be seen that the dairy heifers have a much higher frequency of investigation and licking themselves. It is possible that, due to the restricted and barren conditions of the pens in which the dairy calves are reared, these animals are attempting to increase the level of stimulation they experience by "self-stimulation". The results show that, for these calves, these activities are of short duration but high frequency of

Figure 4.3.9.a.
SEQUENCES OF FIRST-ORDER TRANSITIONS OF BEHAVIOURAL ACTIVITIES OF FIELD CALVES. (AGE = 4WKS)

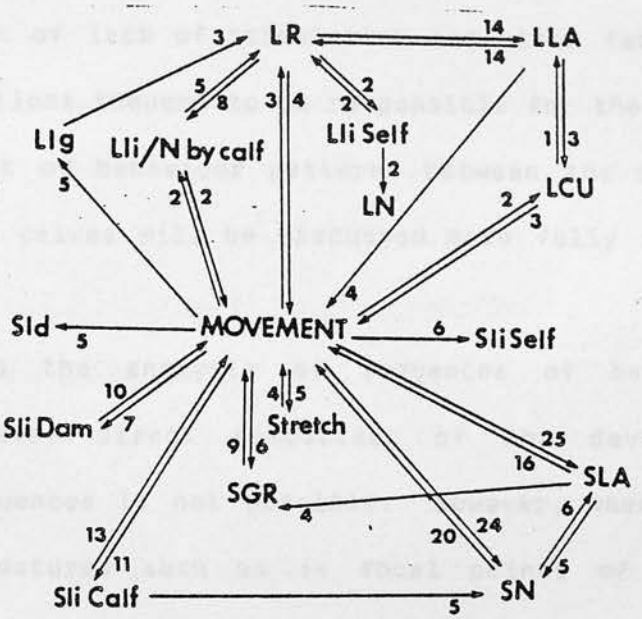
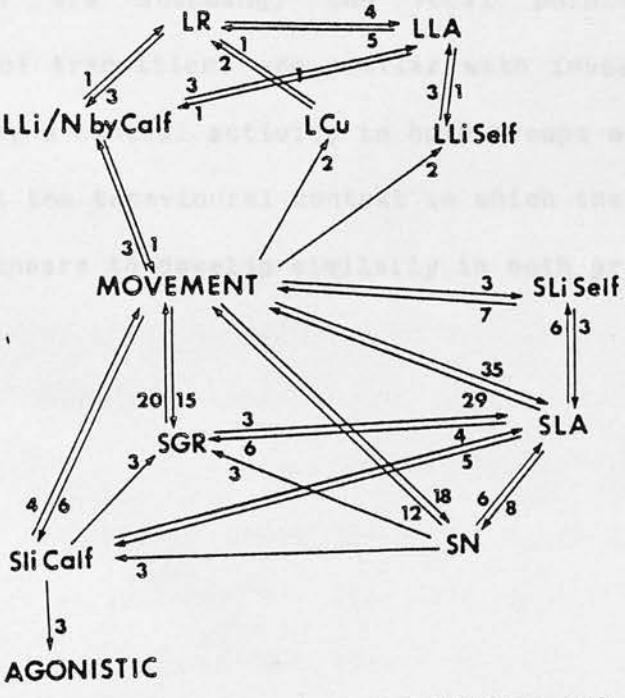


Figure 4.3.9.b.
SEQUENCES OF FIRST-ORDER TRANSITIONS OF BEHAVIOURAL ACTIVITIES OF FIELD CALVES. (AGE = 8WKS)



occurrence, suggesting that there is insufficient stimulation from the environment to maintain the activity.

This aspect of lack of stimulation and other factors of the rearing conditions thought to be responsible for the differences in development of behaviour patterns between the dairy calves and the field calves will be discussed more fully in the final chapter.

Turning to the analysis of sequences of behaviour, as explained above, direct comparison of the development of behaviour sequences is not possible. However, when comparison of general features such as :- focal points of behavioural sequences and directions of transitions are considered (Figures 4.3.6.d & f. and Figures 4.3.9. a & b.), few differences can be observed. For both groups of animals observation is a central activity while the animals are lying down (LLA), although resting (LR) is also a focal point for the field calves. When the animals are standing, the focal points and general directions of transitions are similar with investigation (SN + SLiObj) being a central activity in both groups of calves. This implies that the behavioural context in which the activities are expressed appears to develop similarly in both groups of calves.

4.4. INDIVIDUAL ANALYSIS OF BEHAVIOURAL ACTIVITY

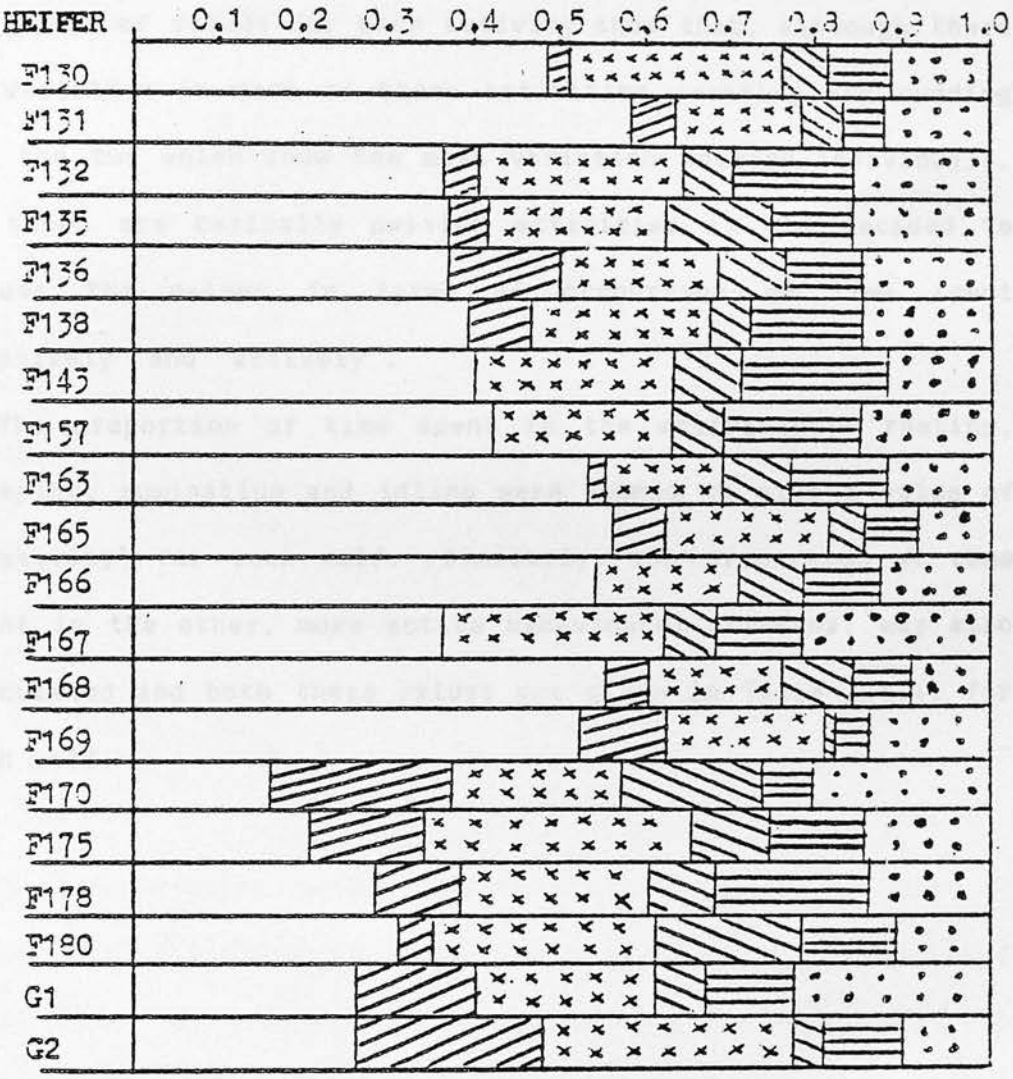
This section deals with analysis of the data of the individual animal to discover whether any calves spend proportionally more of their time in a particular activity than others, and whether they form specific associations, possibly related to the predominant activity of the individuals.

4.4.1. Individual Differences in the Time Spent in Various Activities

The proportion of time spent in resting, ruminating, observation, investigation and ingestion were determined as described in the previous section, but for each individual calf in this case. The mean value of each of these activities was calculated for the five rearing conditions described in this study. Although the distribution of the values for each activity was normally distributed there was no consistency over time in the position of each individual in the distribution. That is, those heifers which were found at the extremes of the distribution in the calf-house with regard to the time they spent resting were not found consistently at the extremes in the subsequent rearing conditions. A similar phenomenon was found for the time spent in the other activities.

The period of time in which the animals are in the calf-house is one in which the animals are least affected by social facilitation in the performance of their behavioural activities. It, therefore, possibly gives the most accurate indication of their individuality. It is also the period in which the stockman has the greatest opportunity to deal individually with

Figure 4.4.1.
PROPORTION OF TIME SPENT IN VARIOUS ACTIVITIES FOR EACH OF THE HEIFERS IN THE STUDY GROUP.



KEY

		RANGE OF VALUES
	RESTING	0.16 → 0.58
	RUMINATION	0.00 → 0.22
	OBSERVATION	0.14 → 0.31
	INGESTION	0.01 → 0.17
	INVESTIGATION	0.04 → 0.18
	OTHER	0.08 → 0.37

the animals, apart from during milking. Figure 4.4.1. shows the relative proportions of the main behavioural activities of the calves during the calf-house period. These and consideration of the range of values for each activity show that, although there is variation in each of these activities, resting and cudding are the two which show the most variation between individuals. As these are basically passive activities it was decided to assess the calves in terms of proportion of time spent "passively" and "actively".

The proportion of time spent in the activities:- resting, sleeping, rumination and idling were summed to give a value of "passivity" for each calf. Similarly, the proportion of time spent in the other, more active behavioural patterns, was also calculated and both these values are given in Table 4.4.1. for each calf.

Table 4.4.1. PROPORTION OF TIME SPENT PASSIVELY AND ACTIVELY WHILE IN THE CALF-HOUSE

HEIFER	PROPORTION OF TIME SPENT PASSIVELY	ACTIVELY
F130	0.54	0.46
F131	0.65	0.35
F132	0.43	0.57
F135	0.45	0.55
F136	0.54	0.46
F138	0.50	0.50
F143	0.42	0.58
F157	0.47	0.53
F163	0.60	0.40
F165	0.64	0.36
F166	0.60	0.40
F167	0.39	0.61
F168	0.66	0.34
F169	0.62	0.38
F170	0.42	0.58
F175	0.40	0.60
F178	0.41	0.59
F180	0.37	0.63
G1	0.47	0.53
G2	0.48	0.52

This measurement of "passivity" for each calf will be used in a later section where investigation of whether it is correlated with other behavioural and production measurements will be attempted.

4.4.2. Individual Differences in Type of Social Encounter

After the calf-house period the calves were reared in groups during which their social behaviour developed. Social behaviour in this study is represented by four activities :- (i) nosing or licking an animal, (ii) being nosed or licked by another animal (iii) initiating an agonistic interaction and iv) agonistic interaction recieved by the focal animal. The development of

social encounters of the group, shown in Figure 4.3.2.e previously, is now divided into the individual expressions of the four activities mentioned above. For each heifer the mean frequency of occurrence per hour of the four social activities is determined over the study period 8-100 weeks and is shown in Figure 4.4.2. The actual values obtained are given in Table J1 of Appendix J. from this it appears that the heifers differ in their types of social encounters.

In general, heifers such as F135 & F138 are sociable as they have a higher frequency of social licking. Whereas, social encounters by heifers such as F131 & F175 tend to have an equal frequency of being expressed either in the form of a licking interaction or in the form of an agonistic interaction. But, some heifers e.g. F168 & F169 have a higher frequency of agonistic encounters within their social contacts. Thus, there appears to be a continuum of social interaction ranging between those animal which react predominately by licking to those which react with an aggressive reaction.

Having shown that individual calves differ in their expression of activities it was attempted to establish whether similar calves formed associations during specific activities.

*Notes - The total number of events initiated and received is not equal, partly due to other animals, not part of the study, being in the study groups and partly due to the method of data collection. The categories of behaviour in the ethogram were considered mutually exclusive, such that if two activities occurred together, the enduring activity was recorded until this was changed by the individual but did not alter its behaviour were not recorded, as was licking received by the focal animal which did not cause the focal animal to cease its ongoing activity.

Figure 4.4.2.
INDIVIDUAL EXPRESSION OF SOCIAL BEHAVIOUR FOR THE HEIFERS OF THE STUDY GROUP.

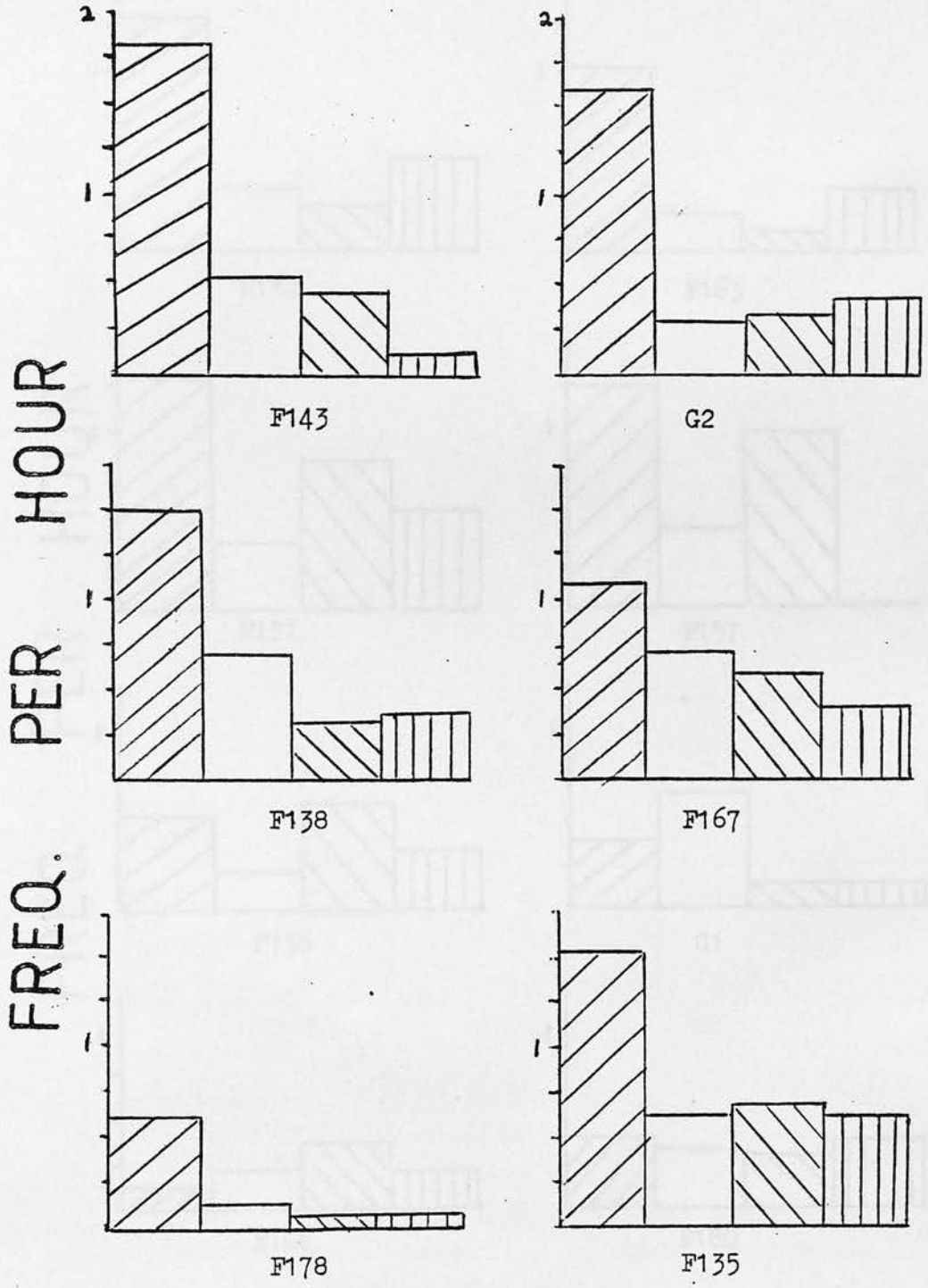


Figure 4.4.2.
INDIVIDUAL EXPRESSION OF SOCIAL BEHAVIOUR FOR THE HEIFERS OF THE STUDY GROUP. (cont.)

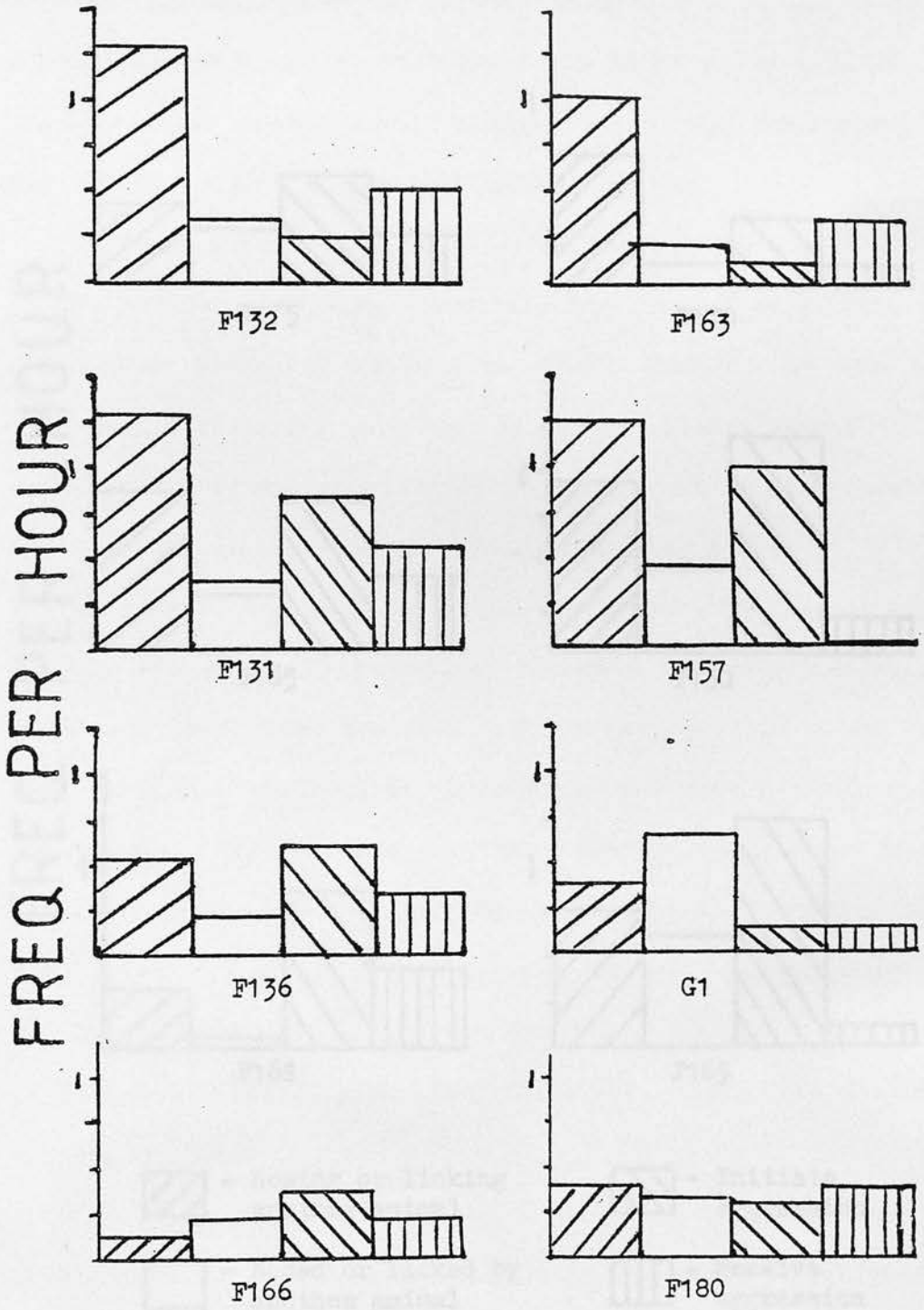
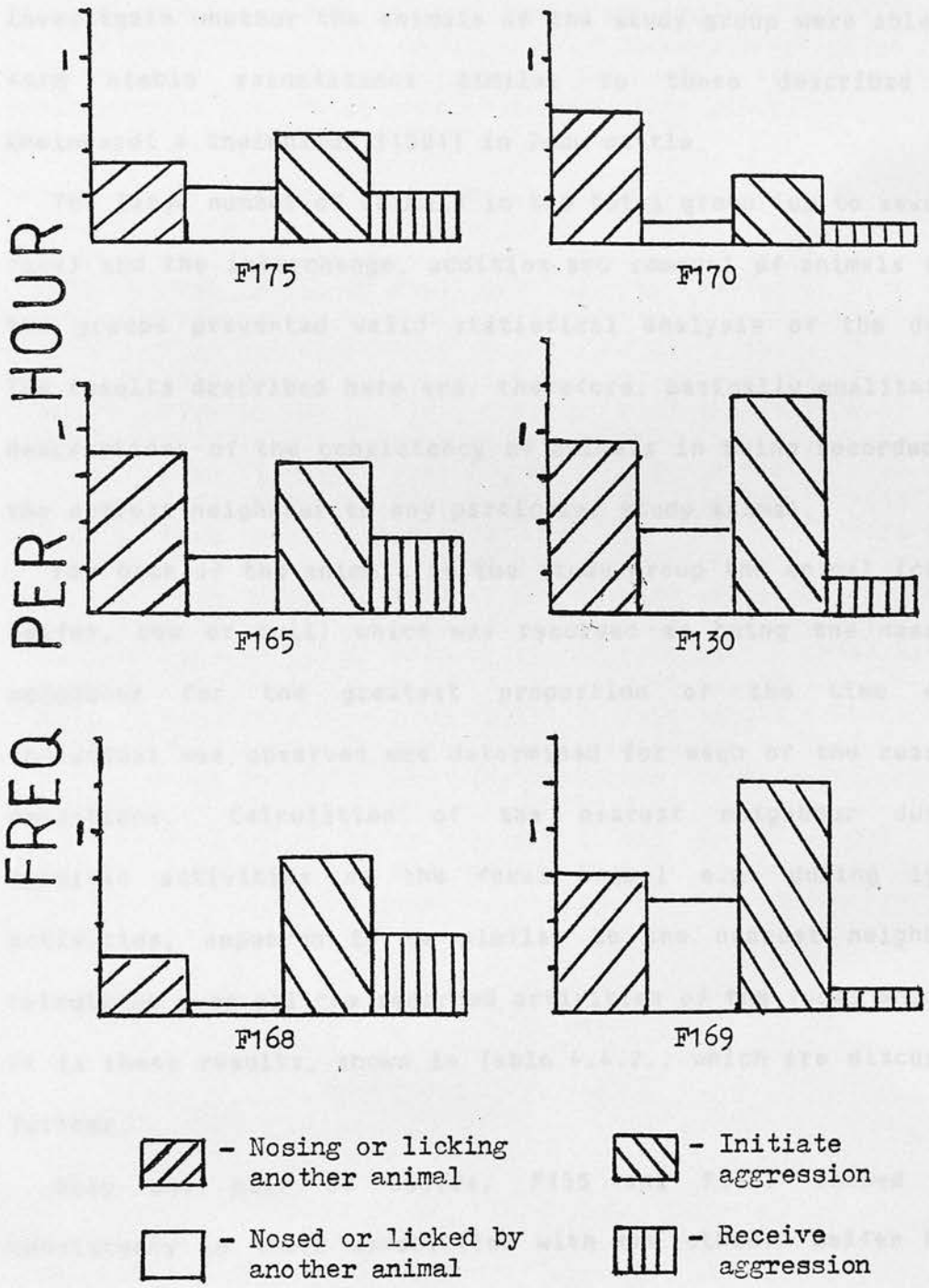


Figure 4.4.2.
INDIVIDUAL EXPRESSION OF SOCIAL BEHAVIOUR FOR THE HEIFERS OF THE STUDY GROUP. (cont.)



4.4.3. Associations Between Heifers

Recording of the nearest neighbour to the individual focal animal, as described in methods section 3.1., was used to investigate whether the animals of the study group were able to form stable associations similar to those described by Rheinhardt & Rheinhardt (1981) in Zebu cattle.

The large number of animals in the total group (up to seventy five) and the interchange, addition and removal of animals from the groups prevented valid statistical analysis of the data. The results described here are, therefore, basically qualitative descriptions of the consistency of animals in being recorded as the nearest neighbour to any particular study animal.

For each of the animals in the study group the animal (calf, heifer, cow or bull) which was recorded as being the nearest neighbour for the greatest proportion of the time each individual was observed was determined for each of the rearing conditions. Calculation of the nearest neighbour during specific activities of the focal animal e.g. during lying activities, appeared to be similar to the nearest neighbour calculated over all the recorded activities of the focal animal. It is these results, shown in Table 4.4.2., which are discussed further.

Only one pair of calves, F135 and F136, showed any consistency in their association with the other. Heifer F136 was observed repeatedly as the nearest neighbour to heifer F135 over a period of twelve months, which involved movement between three environments and the additions of other animals to the

Table 4.4.2. NEAREST NEIGHBOURS OF THE FOCAL ANIMALS DURING THE VARIOUS REARING CONDITIONS

This table shows the individuals which obtained the highest value for the proportion of the total time of observations (given in brackets) that they were recorded as the nearest neighbours to the focal animals i.e. those animals in the study group.

FOCAL ANIMAL	REARING CONDITION (proportion of total observations) CGI	TRANS 2	HGG	TRANS 3	cont. over
F130	F138 (0.43)	F131 (0.22)	F98 (0.11)	F116 (0.18)	
F131	F132 (0.26)	F132 (0.25)	F79/F135(0.12)	F118/F99(0.11)	
F132	F120 (0.24)	F138 (0.34)	F102 (0.10)	F111 (0.11)	
F135	F138 (0.27)	F131 (0.27)	F136 (0.34)	F136 (0.25)	
F136	F135 (0.26)	F135 (0.42)	F135 (0.24)	F135 (0.25)	
F138	F120 (0.27)	F132 (0.32)	F99 (0.12)	F123 (0.19)	
F143	F163 (0.26)	F170 (0.29)	F168 (0.15)	F120 (0.11)	
F157	F166 (0.24)	F163 (0.25)	G5 (0.10)	F167 (0.13)	
F163	F165 (0.36)	F169/F170(0.22)	G8 (0.09)	F175 (0.10)	
F165	F167 (0.24)	F157 (0.31)	G7 (0.12)	F167 (0.24)	
F166	F163 (0.29)	F168 (0.29)	F163 (0.09)	F88 (0.16)	
F167	F168 (0.28)	F163 (0.22)	F166 (0.09)	F88 (0.16)	
F168	F167 (0.36)	F143 (0.40)	F169 (0.11)	F167/F170(0.08)	
F169	F170 (0.39)	F170 (0.57)	F170 (0.18)		
F170	F169 (0.37)	F166 (0.26)	F169 (0.23)	F163 (0.20)	
F175	F170 (0.20)	F166 (0.26)	F169 (0.23)	F163 (0.20)	
F178	F180 (0.23)	G4 (0.33)	G49 (0.11)	G25/G26(0.14)	
F180	G2 (0.22)	G8 (0.22)	F166 (0.15)	G15 (0.17)	
G1	F178 (0.20)	G7 (0.42)	G43 (0.09)	G18 (0.28)	
G2	F180 (0.16)	G18 (0.47)	G1 (0.15)	F178 (0.25)	

Table 4.4.2. cont. from previous

HEIFER	REARING CONDITION (proportion of total observations) HI	TRANS 4	HGG2
F130	G37 (0.17)	F131 (0.22)	G25 (0.10)
F131	F175 (0.07)	G5 (0.16)	F166 (0.11)
F132	F165 (0.11)	G72 (0.11)	F166 (0.10)
F135	F136 (0.12)	G7/F136(0.15)	F136 (0.29)
F136	F127 (0.12)	F131 (0.18)	F135 (0.32)
F138	G5 (0.09)	F135/F136(0.14)	F123 (0.09)
F143	G5 (0.12)	F88 (0.20)	F58 (0.09)
F157	F166 (0.07)	F163 (0.26)	F168 (0.10)
F163	F165 (0.10)	F66/F52(0.14)	F157 (0.14)
F165	F102 (0.12)	F170 (0.19)	F170/F157(0.14)
F166	F163 (0.11)	F180/F132(0.17)	F99 (0.14)
F167	G8 (0.12)	F168 (0.25)	F163 (0.08)
F168	F131 (0.08)	F163 (0.17)	F163 (0.10)
F169		DIED	
F170	F168 (0.11)	G15/G25/F79(0.14)	F175 (0.12)
F175	F112 (0.10)	F180 (0.16)	F168 (0.11)
F178	F168 (0.09)	F180 (0.16)	F168 (0.13)
F180	G7 (0.11)	G23 (0.21)	F167/G1(0.15)
G1	G41 (0.09)	F180 (0.18)	G2 (0.19)
G2	F132 (0.15)	F167 (0.34)	G5 (0.10)

NOTE - The abbreviations :- CH, CGI, HG1, HI and HG2 represent the rearing conditions - calf-house, calves grouped indoors, first grazing period, heifers housed indoors and second grazing period of heifers respectively.

group. Similarly, heifer F135 was found to be the nearest neighbour to F136 over the whole study period (24 months) except for the yard and cubicle rearing condition where it was the second nearest neighbour to heifer F136. This is probably due to heifer F136 being successfully inseminated before heifer F135 and being removed to the other side of the yard and grouped with the bull.

The only other association which showed any consistency was between heifers F169 and F170, however as heifer F169 died at approximately eleven months of age it was impossible to observe whether this association would have continued.

The consistency of these two associations just described may be explained by the fact that each association was between a pair of twins i.e.heifers F135 & F136 and heifers F169 & F170 were twins.

Within the rest of the group there were fifteen instances in which an animal which had previously been the nearest neighbour to an individual calf was again the nearest neighbour at a later age. Of these, twelve of the fifteen instances (80%) involved animals which were the nearest neighbour to an individual calf during the first seven months of being grouped together. This coincides with the period in which the frequency of social encounters is at a peak (see Figure 4.3.3.e).

In each of the rearing conditions the animal which was recorded as the nearest neighbour to all the twenty heifers in the study group did not actually contribute more than 7% of the total recorded instances of nearest neighbours, suggesting that no

individual animal was a common neighbour to the heifers in the study group. A summary of the associations described above can be found in Table J2 of Appendix J.

4.5. INDIVIDUAL REACTIVITY OF THE HEIFERS

This section deals with the analysis of the data collected on the reactivity of the animals to being touched by the observer and their behaviour during milking to establish whether the heifers develop differences in their type of reaction.

4.5.1. Reactivity to Being Touched by the Observer

The scores for reactivity to being touched were obtained as described in the methods section 3.1. A mean score was determined for each individual animal during the calf-house period and then over periods of approximately eight weeks in the same environment for the other rearing conditions (i.e. calves grouped indoors after weaning, 1st grazing period of heifers etc.). As each of the rearing conditions were approximately 8 weeks, 4 months, 6 months, 6 months and 5 months respectively, this resulted in one mean value for each heifer during the calf-house period, two mean values while grouped together indoors and three mean values while grazing in the first period, while housed in the yard over winter and while grazing for the second time. A table of the number of scores contributing to the mean, the mean score and its standard deviation for each individual heifer in the study group is given for the periods described above in Table K1 of Appendix K.

The values are presented here graphically in Figures 4.5.1. a-d. These figures show that approximately 75% of the group (16/20) are relatively consistent in their reaction to being touched. In some cases this is temporarily affected by a change

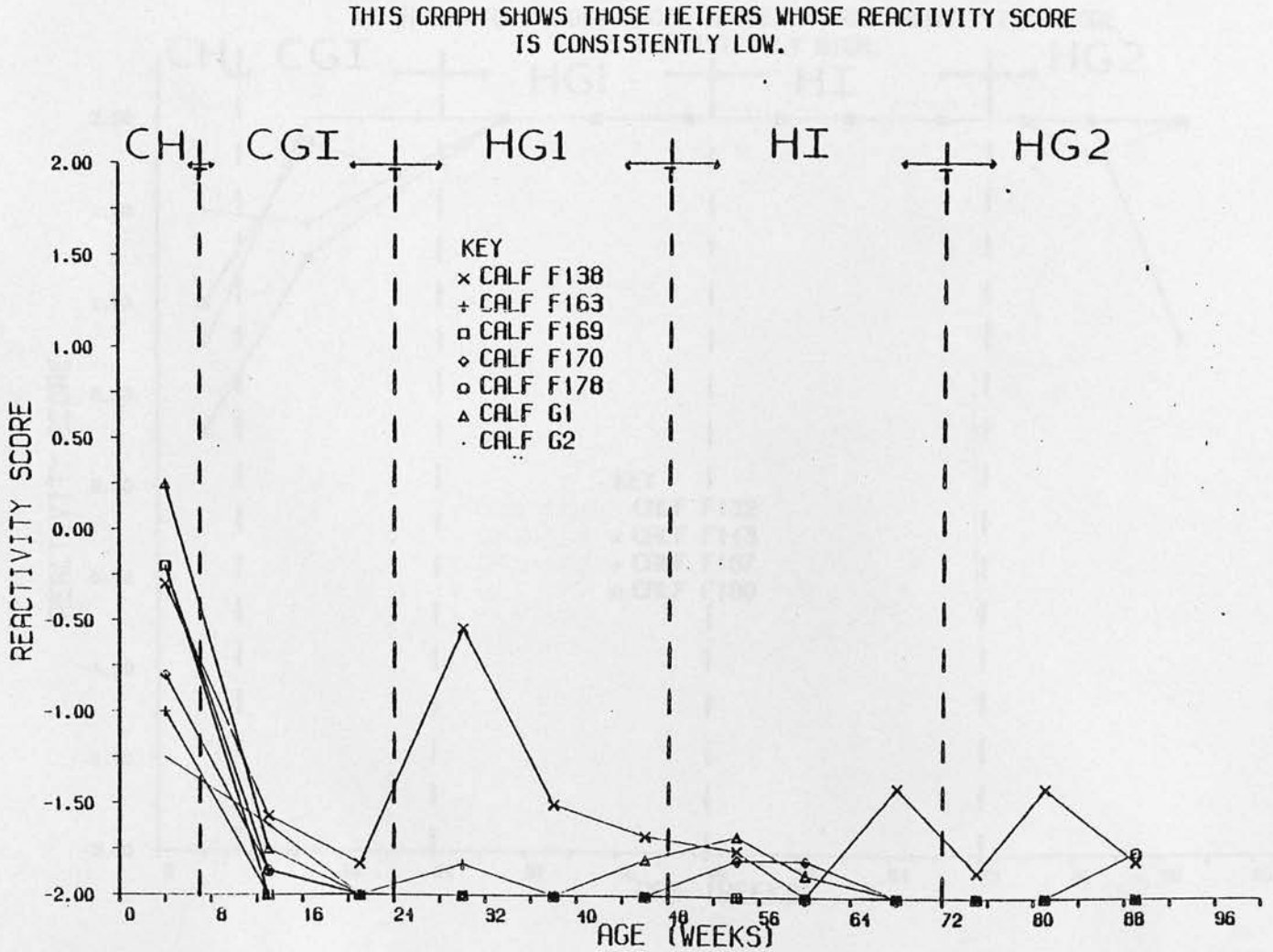


Figure 4.5.1.a) DEVELOPMENT OF CALVES REACTIVITY TO BEING TOUCHED

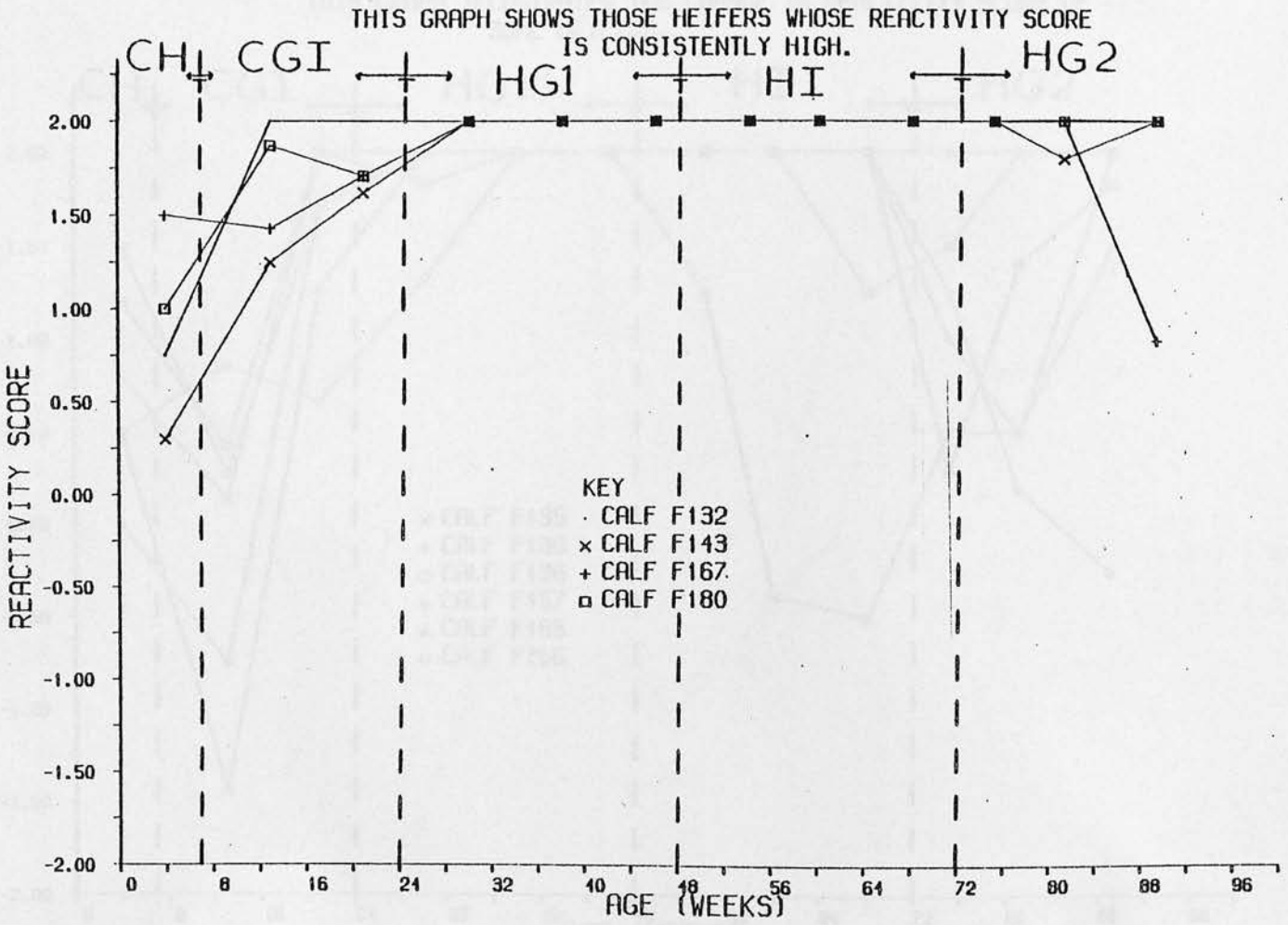


Figure 4.5.1.b) DEVELOPMENT OF CALVES REACTIVITY TO BEING TOUCHED

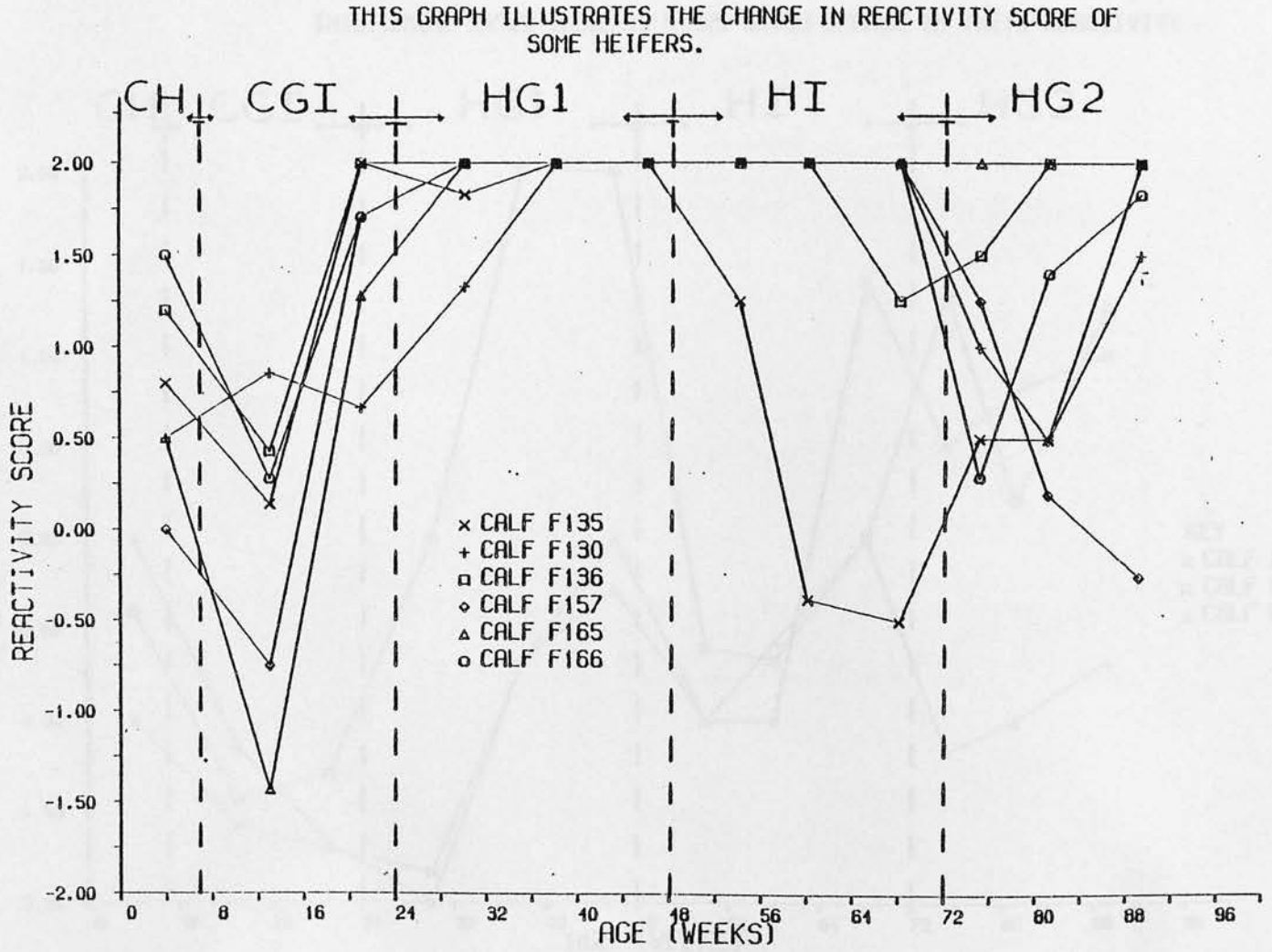


Figure 4.5.1.c) DEVELOPMENT OF CALVES REACTIVITY TO BEING TOUCHED

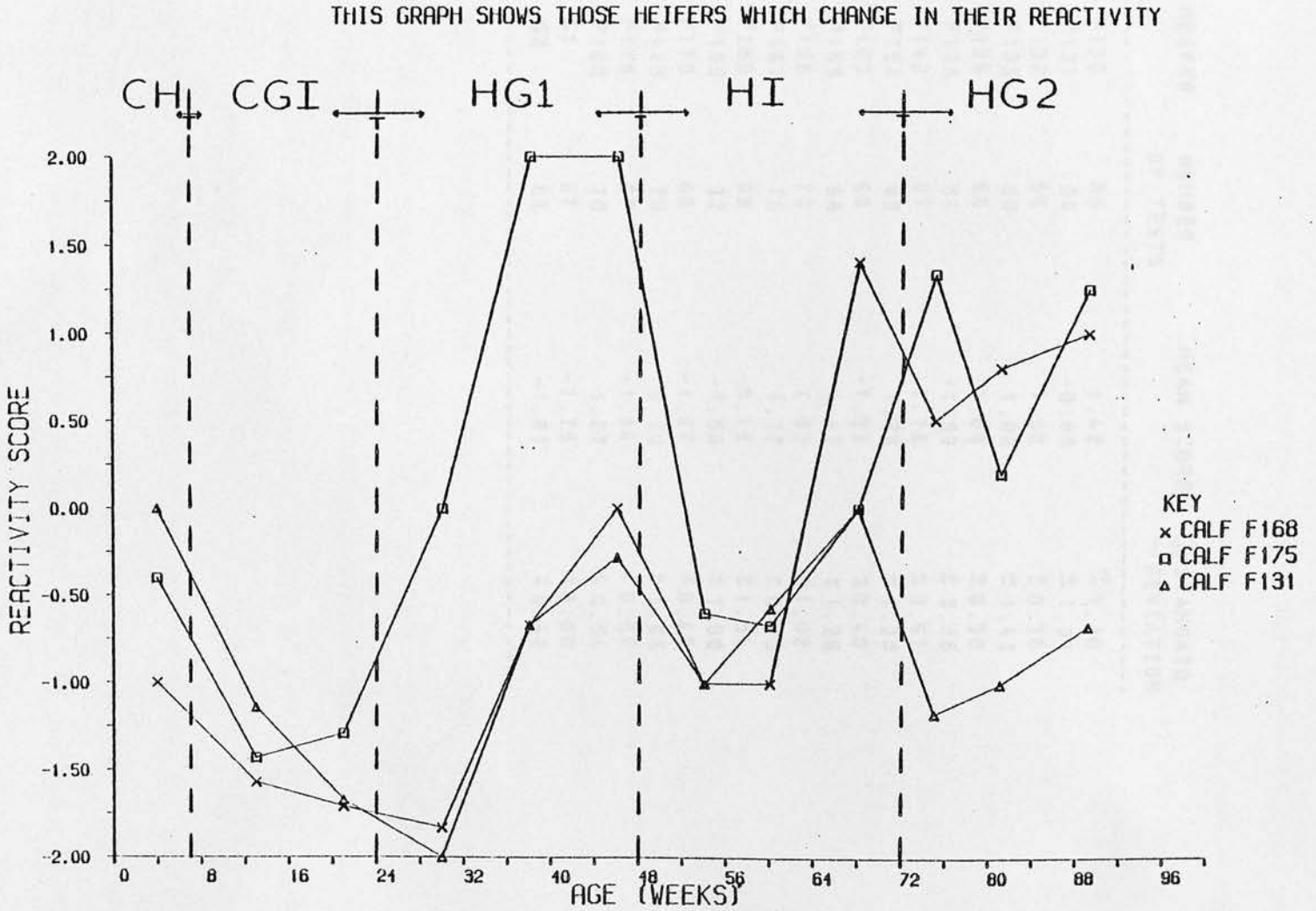


Figure 4.5.1.d) DEVELOPMENT OF CALVES REACTIVITY TO BEING TOUCHED

Figure 4.5.1.
MEAN SCORE FOR REACTIVITY TO TOUCH FOR THE HEIFERS OF THE STUDY GROUP OVER THE WHOLE STUDY PERIOD.

HEIFER	NUMBER OF TESTS	MEAN SCORE	± STANDARD DEVIATION
F130	66	1.42	± 1.20
F131	66	-0.86	± 1.01
F132	66	1.92	± 0.36
F135	66	1.06	± 1.41
F136	66	1.68	± 0.90
F138	64	-1.59	± 0.66
F143	67	1.78	± 0.67
F157	65	1.26	± 1.30
F163	68	-1.93	± 0.40
F165	68	1.47	± 1.26
F166	70	1.53	± 1.02
F167	70	1.77	± 0.73
F168	69	-0.48	± 1.54
F169	32	-1.66	± 1.00
F170	69	-1.87	± 0.45
F175	70	0.20	± 1.66
F178	67	-1.84	± 0.57
F180	70	1.87	± 0.54
G1	67	-1.79	± 0.66
G2	67	-1.91	± 0.42

in the rearing environment of the animal. However, given sufficient time within that condition the individuals reaction to being touched becomes consistent.

Generally, those animals which have a score greater than zero initially, tend to increase their score showing a consistently positive reaction to being touched, whereas those whose initial score is low tend to remain low. As most of the individuals in the group tended to show the same reaction to being touched throughout the study the overall mean reactivity of the heifers was calculated (Table 4.5.1.). This is used in the next section in which correlation of the reactivity score with other measurements is investigated.

4.5.2.

Behaviour at Milking and Assessment of Milking Temperament

Having found differences in the heifers reactivity to being touched, their reactivity to being milked was investigated. The data collected on the heifers when they were entering the parlour was analysed using the Chi-square test statistic to determine whether movement into the parlour was at random and whether it was influenced by the action of the dairyman. The null hypothesis (H_o) was :- that the position within the milking group on entering the parlour is independent of whether entry is a free choice or a forced choice. Thus the expected values of the matrix were determined by multiplying the marginal totals common to a particular cell and then dividing the product by the total number of observations (Siegel 1956), as shown in Table

4.5.2.

As the chi-square value obtained is greater than that associated with the $p < 0.001$ level of significance, the null hypothesis is rejected in favour of the alternative hypothesis. The alternative hypothesis being :- the frequency of entering the parlour within a certain position in the milking group is not at random and is associated with the mode of entry i.e. free or forced movement.

Table 4.5.2.

CHI-SQUARE TEST OF MOVEMENT INTO THE MILKING PARLOUR.

POSITION IN THE MILKING GROUP ON ENTRY TO PARLOUR		EASE OF ENTRY TO PARLOUR FREE CHOICE	PUSHED	TOTAL
FIRST THIRD	observed	52	17	69
	expected	34.4	34.6	
MIDDLE THIRD	observed	45	26	71
	expected	35.4	35.6	
LAST THIRD	observed	39	94	133
	expected	66.3	66.7	

$\chi^2 = 45.55$, with d.f.=2,
has probability of occurrence $p < 0.001$.

In particular, when the differences between the observed and expected values are considered individually it can be seen that more of the individuals which entered the parlour in the last third of the milking group were pushed in than would have been expected had position in milking group and ease of entry to the parlour been a random event. Similarly, more individuals which entered the parlour within the first third of the milking group

did so freely with fewer being pushed in than would have been expected.

As described in section three, each milking group was composed of 48 - 50 animals, approximately 10% of which were heifers, the remainder of the group being multiparous cows. The results obtained on the behaviour of heifers entering the parlour during milking suggest that in general heifers within the herd tend to enter the parlour last and are generally pushed in by the dairyman. A few however, appear to enter the parlour irrespective of position in the group or by movement enforced by the dairyman. In an attempt to consider individual differences in the ease of entry to the parlour the proportion of times an individual was observed to be pushed into the parlour was calculated, this being associated with position within the milking group (as shown in Table 4.5.2.). These values, given in Table 4.5.3., suggest a continuum within the study group of "reluctance" to enter the parlour. This ranges between animals which enter the parlour freely at any time during milking and those which enter when forced to do so by the dairyman.

Table 4.5.3.

PROPORTION OF TIMES INDIVIDUAL HEIFERS WERE PUSHED INTO THE PARLOUR

HEIFER	NUMBER OF OBSERVATIONS	PROPORTION TIMES PUSHED INTO PARLOUR
F143	28	0.18
F132	26	0.27
F170	28	0.29
F138	20	0.45
F157	26	0.46
F168	10	0.50
F180	21	0.57
F163	25	0.60
F166	25	0.60
F136	20	0.75
F167	18	0.78
F175	21	0.81

The behavioural activity of the heifers recorded during milking was used to score the animals temperament in a similar manner as that used by Dickson et al (1970) described in the literature review (see Figure 3.1.1 in section 3.2.7.). The mean values and standard deviations of the scores recorded for each of the individuals observed in the parlour are given in Table 4.5.4.

Table 4.5.4.
MEAN MILKING TEMPERAMENT SCORE OF THE HEIFERS IN THE STUDY GROUP THAT WERE OBSERVED DURING MILKING.

HEIFER	NUMBER OF OBSERVATIONS	MEAN SCORE + S.D.
F130	7	3.86 + 0.38
F132	14	1.14 + 0.53
F136	24	2.12 + 0.99
F138	18	2.06 + 1.16
F143	23	1.26 + 0.62
F157	27	1.63 + 0.57
F163	25	2.00 + 0.50
F166	26	2.31 + 0.79
F167	18	1.89 + 0.67
F168	10	2.00 + 0.47
F170	27	2.07 + 0.55
F175	22	1.82 + 0.50
F180	21	1.81 + 0.60

A low mean score represents an individual which was classed as having a relatively good milking temperament. An individual with a high mean score would be regarded as having a relatively bad milking temperament (see section 2.2.5.). These values are used in the next section to determine whether milking temperament is correlated with other individual behavioural measurements and with some production measurements.

4.6. PRODUCTION MEASUREMENTS AND INVESTIGATION OF CORRELATION BETWEEN BEHAVIOURAL AND PRODUCTION MEASUREMENTS

In this section the production data (available from Langhill Farm records, with the kind permission of Mr. L. Hodgson-Jones and Mr. H. Parkinson) is presented. This section also investigates whether there is any correlation between these and the individual behavioural measurements described in the previous sections.

4.6.1. Production Data

From the farm records it was possible to obtain measurements of liveweight of the individuals in the study group at various ages throughout their rearing. The actual values are given in Appendix I.. Co-efficients of regression, using the Genstat computer package, were calculated for each individual animal and are shown in Table 4.6.1.

Table 4.6.1.
REGRESSION CO-EFFICIENTS OF WEIGHT GAIN OVER THE STUDY PERIOD FOR THE INDIVIDUAL HEIFERS

HEIFER	REGRESSION CO-EFFICIENT	STANDARD ERROR	HEIFER	REGRESSION CO-EFFICIENT	STANDARD ERROR
F130	0.723	± 0.026	F166	0.657	± 0.028
F131	0.764	± 0.015	F167	0.673	± 0.035
F132	0.765	± 0.017	F168	0.688	± 0.039
F135	0.692	± 0.032	F169	0.771	± 0.054
F136	0.754	± 0.036	F170	0.770	± 0.037
F138	0.741	± 0.034	F175	0.746	± 0.024
F143	0.663	± 0.028	F178	0.756	± 0.031
F157	0.743	± 0.047	F180	0.677	± 0.034
F163	0.706	± 0.032	G1	0.747	± 0.040
F165	0.619	± 0.044	G2	0.632	± 0.028

Measurements of the heifers milk yield were taken once a week. The values recorded within the first fifteen days after calving were excluded from the analysis as this represents the early lactation peak. The remaining recordings were used to evaluate the average daily milk yield of the individuals. These values are shown in Table 4.6.2.

Table 4.6.2.
AVERAGE DAILY MILK YIELDS (Kg) OF THE HEIFERS.

HEIFER	NUMBER OF RECORDS	MEAN DAILY YIELD	STANDARD DEVIATION
F132	20	23.96	± 1.957
F135	2	27.50	± 0.707
F136	20	23.34	± 2.812
F138	20	25.64	± 2.252
F143	20	26.73	± 6.732
F157	20	27.09	± 2.357
F163	18	25.07	± 1.609
F165	4	21.03	± 1.101
F166	19	22.08	± 2.012
F167	18	28.51	± 1.146
F168	16	24.12	± 1.768
F170	19	24.57	± 3.274
F175	19	24.17	± 2.104
F180	18	14.01	± 0.962

Correlation between these results and those obtained from the analysis of the heifer's behaviour is now investigated.

4.5.2. Investigation of Relationships Between Behavioural and Production Measurements.

Relationships between the various measurements obtained for each of the heifers was considered in two main ways :-

1)Relationships between behavioural measurements and,

2)Relationships between behavioural and production measurements.

To determine the association between any two of the measurements, the coefficient of correlation (r), was calculated for each pair of variables according to the equation given in Figure 4.6.1.

Figure 4.6.1. CORRELATION COEFFICIENT CALCULATION

(from Snedecor & Cochran 1980)

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

$$r = \frac{\sum x_i y_i - \frac{\sum x_i \sum y_i}{n}}{\sqrt{\left[\sum x_i^2 - \frac{(\sum x_i)^2}{n}\right]\left[\sum y_i^2 - \frac{(\sum y_i)^2}{n}\right]}}$$

A summary of the coefficients of correlation obtained between the behavioural measurements is given in Table 4.6.3.

Table 4.6.3. RELATIONSHIPS BETWEEN BEHAVIOURAL MEASUREMENTS

MEASUREMENT	CORRELATION COEFFICIENT (r) for correlation with measurement :- 1	2	3	4	5	6
1)Proportion time spent passively as calf	---	-0.177	0.433+	-0.181	0.068	0.390
2)Frequency/hr initiate social licking		---	0.079	0.041	-0.513+	-0.267
3)Frequency/hr initiate aggression			---	0.260	0.228	0.576*
4)Mean score for reaction to touch				---	0.149	-0.076
5)Proportion times pushed into parlour					---	0.521+
6)Mean score for milking temperament						---

* $p < 0.05$
\+ $p < 0.10$

This shows that only the coefficient of correlation between the frequency of initiating aggression and milking temperament was significant ($p<0.05$). However, the coefficients of

correlation between :- proportion of time spent passively as a calf & frequency of initiating aggression, frequency of initiating social licking & proportion times pushed into parlour and proportion of times pushed into parlour & milking temperament tended towards this level of significance. Although it may be expected to obtain one significant correlation coefficient by chance, the fact that three other correlation coefficients are nearly significant suggests that there are relationships between the measurements and that the information may be used to formulate a hypothesis. As these measurements are taken at various stages throughout the calves development it may be that the measurements are related in a developmental way. This hypothetical trend in development of the various behavioural features is discussed fully in the next chapter.

Investigation of relationships between behavioural and production measurements revealed little association between any of the measurements (see Table 4.6.4.).

Table 4.6.4.

RELATIONSHIPS BETWEEN BEHAVIOURAL AND PRODUCTION MEASUREMENTS

BEHAVIOURAL MEASUREMENT	PRODUCTION MEASUREMENT	
	GROWTH RATE correlation coefficient with :-	MEAN DAILY MILK YIELD
Proportion time spent passively as calf	-0.121	-0.063
Freq/Hr initiate social licking	-0.166	0.623*
Freq/Hr initiate aggression	0.067	0.321
Mean score reaction to being touched	-0.358	-0.199
Proportion times pushed into parlour	-0.074	-0.299
Mean score for milking temperament	0.000	-0.151

* $p < 0.05$

Only the coefficient of correlation between the frequency of initiating social licking and mean daily milk yield reached the $p < 0.05$ level of significance.

It is possible that with a larger number of animals that the measurements would show a higher degree of correlation. These results are discussed further in the next section.

CHAPTER 5 DISCUSSION, SUMMARY AND CONCLUSIONS

5.1. INTRODUCTION

So far this project has attempted to investigate the development of behaviour patterns of dairy calves reared in intensive conditions in an attempt to compare it with the information available on the behavioural development of conspecifics reared in the field. The behavioural development covered areas of general development of time budgets and the change in relatedness of behaviour patterns over time, individual variation in the expression of activities and associations between individuals, and the variation between individuals to being handled especially during milking with its associated stressors. The main features of intensive rearing which were thought to affect their development are :- 1)feeding highly nutritious foodstuff e.g. milk-replacer feeding of calves, silage & concentrate food during housing, 2) lack of social contact, initially with its dam and peers and later with older animals of both sexes, 3)instability in group composition and 4)unfamiliarity with milking parlour and stressors associated with milking. The results obtained in this study are now discussed in relation to these points and the findings of other authors where available.

5.2. DISCUSSION OF RESULTS

5.2.1. Time Budgets

Dairy calves normally receive most of their nutritional requirement in two periods of bucket feeding of a milk-replacer which is consumed rapidly. Normally they would obtain this in several suckling bouts lasting 5 - 15 minutes (Hafez 1975). The question of what they do with time normally spent in suckling was proposed by Kiley-Worthington (1977) for calves reared for veal, which were also restricted in their movement. Most of the comparisons of time budgets which follow extend to approximately six months of age. Few studies observed the animals after this age. However, most calves reared with their dams would normally be in the process of weaning at this time and would therefore be expected to show time budgets similar to that of the dairy calves in this study, which by that age are also grazing.

Comparing the time budgets obtained in this study (Figs. 4.3.2. and 4.3.3.) for dairy heifer calves with those of crossbred calves reared with their dams (Nicol & Sharafeldin 1975, Kiley-Worthington & De La Plain 1983 and Wood-Gush *et al* 1984) is useful in determining whether alteration of the time spent in an activity, or the frequency of its occurrence, has taken place. During the period when the dairy calves are reared in individual pens i.e. approximately first eight weeks of age, the general trend of their behavioural development is similar to that of the crossbred calves in that they became more active, increased their consumption of solid food and time spent ruminating while tending to decrease the time spent resting or

sleeping. However, the actual proportion of the time spent in certain activities and the age at which they increased or decreased was different for certain activities. In particular, although the proportion of time spent feeding was similar for intensively and extensively reared calves, the proportion of time spent cudding increased to a higher level in the dairy calves. This greater amount of time spent ruminating by confined calves raised for veal compared to field calves of a similar age was reported by Kiley-Worthington (1983), who suggested that these animals may have been partly "pseudo-ruminating" as described by Gordon (1958). The crossbred calves in the study by Wood-Gush et al (1984) spent more time investigating the environment than that recorded for the dairy calves. Indeed the crossbred calves increased the amount of time they spent in investigation over the first eight weeks whereas the dairy calves decreased the proportion of time they spent investigating the environment after four weeks of age, suggesting that the environment was limiting as a stimulus for investigation. Further, the tendency to investigate does not decline i.e. the frequency with which the dairy calves commenced to investigate the pen remained high over the eight weeks, but the duration of the activity declined indicating that the pen was insufficient to sustain investigation for any length of time after four weeks of age. A further alteration in the behavioural development of dairy calves over this period is the greater frequency in licking themselves compared to extensively reared calves (Wood-Gush et al 1984). Kiley-Worthington (1983)

found that confined calves reared for veal also spent more time self-grooming than field calves and suggested that it could also be due to the lack of stimulation from the environment and could use up "spare" time. Possibly in an attempt to increase stimulation, the dairy calves increased their social contact with other calves, shown by an increase in the frequency of licking another calf. This required a degree of effort by the calf as contact was limited by the presence of a partition between the pens and by the size of the calf. They also had a much higher frequency of activities associated with play (jumping up and down or backwards and forwards or shaking its head) than crossbred calves (Wood-Gush et al 1984). However, as the dairy calves are weaned at eight weeks of age and transferred to larger pens with other calves of similar age the lack of stimulation is not a long lasting experience.

Upon grouping after weaning the dairy calves have to obtain their nutritional requirements from hay and concentrate foods alone. This appears to be achieved in a much shorter time (especially so when the calves are transferred to silage feeding) than crossbred calves (Nicol & Sharafeldin 1975) or castrated dairy bull calves reared on grass (Roy et al 1955). This is possibly due to the component of searching and selection of food involved in grazing. Nicol & Sharafeldin (1975) found that crossbred calves of 4.5 months of age had a grazing time which represented approximately 70% of the adult grazing time. However, the time spent ruminating by the dairy calves was still higher than the crossbred calves, although those in the study by

Kiley-Worthington & De La Plain (1983) developed a similar amount of time spent ruminating as the dairy calves.

The amount of time spent on investigation was higher in dairy calves than in crossbred calves (Kiley-Worthington & De La Plain 1983), possibly due to the transfer to a new environment for the dairy calves. Towards the end of this period indoors (approximately six months of age) the time spent on investigation decreased to a low level similar to that reported for crossbred calves (Kiley-Worthington & De La Plain 1983). The frequency of investigation also increased over this rearing period for the dairy calves. It is possible that social facilitation is the reason for the increase in investigation. It may also be that the high level of investigation in the crossbred calves from birth to eight weeks in the study by Wood-Gush et al (1984) was due to the social facilitation of their dams and peers. The dairy calves in this study showed a lot of interest in their peers, upon being grouped, and this is shown by the increase in social licking and the frequency of agonistic interactions (see Fig.4.3.3.e). The amount of time spent, and the frequency of occurrence, of self-grooming in dairy calves, previously higher than crossbred calves (Kiley-Worthington & De La Plain 1983 and Wood-Gush et al 1984) decreases to a level similar to that of crossbred calves and tends to remain at that level.

When the dairy calves are turned out to pasture they soon develop a similar amount of time spent grazing as observed previously for crossbred calves (Nicol & Sharafeldin 1975) or

castrated dairy bull calves reared at grass (Roy et al 1955). The amount of time spent ruminating is also similar to that of the dairy bull calves in the study by Roy et al (1955). For the remainder of the study, incorporating two grazing periods and a period of housing over the winter, the time budget of the dairy heifer appears to be similar in both grazing periods, with only an increase in the proportion of time spent grazing, and a slight decrease in the time spent on investigation, observation and resting. In fact, the time budget of the heifer for grazing, ruminating and resting in the second grazing period i.e. 20 - 25 months of age, is similar to that reported for mature cows with only grazing being slightly less than the adult value (Hughes & Reid 1951, Hancock 1953 and Low, Tweedie, Edwards, Hodder, Malafant & Cunningham 1981).

Most alterations in the time budget ocurred when the heifers were housed for the winter. In general, as no studies of cattle of this age could be found for comparison, the proportion of time spent ingesting silage was much shorter than the time spent grazing (see Fig. 4.3.2.c), probably due to both the higher energy content of the silage and the component of time spent searching and selecting food during grazing. Yet, the proportion of time spent ruminating increased during this period. Another altered feature in this period is that it is the only period where the ratio of lying to standing is less than one, i.e. the heifers are standing more of the time than they are lying. Three suggestions are offered here to explain the alterations in the heifer's time budget. Firstly, the

heifers are now managed more intensively with ad libitum silage and routine operations such as cleaning and bedding. Also the yard is located at the centre of the farm where there is a lot of activity. This could explain the proportion of time spent in observation in this period compared with the grazing periods (see Fig. 4.3.2.b). However, as the frequency of observation is lower than during the grazing periods (Fig.4.3.3.b) it would appear that observation is usually of long duration and not of the short frequent pattern recorded during grazing. It is possible that observation here is serving to occupy some of the "spare" time experienced by the heifers which are not having to search for their food. Thus some of the rumination may in fact be "pseudo - rumination" as described previously. The increase in frequency of self-grooming in this period may also be an attempt to reduce the amount of "spare" time. Another possibility is that the heifers are approaching puberty in this period and behavioural actions such as mounting and increased activity may disturb other heifers resting. In addition, heifers observed in oestrus are removed from the group by the stockman and tethered in a stall to await artificial insemination. This would explain the lower proportion of time spent resting by the heifers (Fig. 4.3.1.). However, there does not appear to be an increase in the frequency of movement (Fig. 4.3.3.b), although the slight increase in frequency of agonistic interactions during this period may suggest that the heifers which are disturbed by oestrus heifers react by pushing or threatening them rather than by moving away. The third

suggestion is that the heifers are unaccustomed to cubicles and concrete slatted passages. This would account for the lower proportion of time spent resting by the heifers. In addition, the cubicles which are wooden-based and located in the yard, rather than in the building with the slatted passage, were always occupied with any vacancy being filled immediately by cows standing in the vicinity, even though free stalls were available inside the building. The change in activity of the heifers during this period is most probably a combination of all three suggestions.

Although the time budget appears to be mainly affected by the rearing environment, the context of the activities, shown by the sequence analysis, appears to change more with the age of the animal rather than changes in its environment. From the sequence analysis it can be seen that, in general, as the heifer develops its behavioural sequences become more fixed in pattern. This is shown by the gradual decrease in the number of transitions between activities and an increase in the association between activities as the heifer matures. In particular, investigation ceases to be a central activity at about eight months of age and it is replaced by movement as a central activity, which is closely associated with grazing and observation in a sequence of behavioural acts. Rumination is generally associated with activities occurring when the animal is lying down resting.

Comparison of focal points and direction of transitions in sequence diagrams for behavioural sequences of intensively and

extensively reared calves (see section 4.3.3.) were found to be similar for both groups. This suggests that integration of activities into developing behaviour patterns of calves is determined ontogenetically with little modification by environmental factors. Environmental stimuli appear to influence the relative proportion or frequency of an activity rather than its relationships within the individual's behavioural repertoire.

More information on the development of time budgets of cattle in an extensive environment throughout its rearing i.e. until maturity, would be valuable here in indicating the extent to which the rearing condition is influencing the development of the behaviour patterns of dairy heifers.

5.2.2. Individual Expressions of Activities and Associations

Having established that in general dairy calves differ in the proportion of time they spend in activities compared to calves reared in an extensive environment, possibly due to the dairy calves occupying time normally spent suckling with other activities, the individual time budgets of the calves is now considered. Over the calf-house rearing period it appeared that calves varied in how they occupied their "spare" time (see Fig. 4.4.1.). Some calves spent more time lying resting (e.g. F131, F168, F165), others increased the amount of time spent ruminating (possibly "pseudo-rumination" e.g. F170, G2). These strategies for adapting to a restricted environment were also observed by Kiley-Worthington (1983) for dairy calves reared for

veal. In that study, some calves showed possible stereotyped behaviour in that they performed a lot of self-stimulation and activities characteristic of frustration e.g. kicking, scratching, rubbing, chewing, licking. Although the calves in this study did show differences in their adaptation to restricted conditions the formation of stereotyped behaviour was not apparent.

Following the calf-house period the calves are grouped together for the first time. Their adaptation to social contact also varies (see Fig. 4.4.2.). Some calves were involved predominately in social licking following a social encounter whereas others responded agonistically. Although little information is available for young animals these differences in aggressiveness are extensively reported for mature animals (e.g. Allee 1932, Woodbury 1941). Indeed, most studies which attempt to establish the hierarchial structure of a group use measures of aggressiveness to rank the individuals (Alba & Asdell 1946, Schein & Fohrman 1955, Guhl & Atkeson 1959, Beilharz, Butcher & Freeman 1966, Reinhardt 1973, Friend & Polan 1974, Reinhardt & Reinhardt 1975, Clutton-Brock & Greenwood 1976, Collias 1976 and Beilharz & Zeeb 1982).

Reinhardt & Reinhardt (1981) found that particular individuals, in a semi-wild zebu cattle herd, were involved in a lot of social licking. They also found that during social licking the formation of associations between pairs of individuals was apparent. Associations were also found between individuals during grazing and they suggested that associations

during other activities was possible. In this study few permanent associations were formed for any particular activity. The only association which was sustained throughout the two year period was that between a pair of twins. Of the remainder of the group most of the associations observed towards the end of the study were between heifers which had previously formed an association at an earlier age. It may be that initial encounters of individuals are sustained and that outside variables such as movement of animals from group to group affects the stability of such associations. Maintaining animals in the same group throughout the rearing period may facilitate the formation of stable associations between individuals. It is possible that after joining the milking herd, where the heifers are usually in the same group of animals for a long period of time, that associations become more permanent.

5.2.3.

Relationships Between Behavioural Measures of the Individual

Differences in the way individuals spend their time may also be reflected in measures of their emotionality e.g. reaction to handling, temperament during milking. For example, an individual which spent more time passively as a calf may be less curious than those which spent more time actively. It may therefore be expected to react aversively towards handling as it was not accustomed to reacting to stimuli. Alternatively, it may be that the animal would react in the same way to all stimuli and may generally have a passive reaction towards all

things i.e. when presented with "spare" time it expresses a passive activity such as resting or ruminating.

In an attempt to understand the animal more fully, the reactivity to being touched was assessed throughout the study. The results obtained were interesting in that most of the individuals were consistent in their reaction to being touched. A few individuals did change in their reaction to being touched and in all cases they changed from moving away to allowing touching.

There appeared to be little relationship between the individuals reaction to handling and its other behavioural measurements. This could, in part, be due to the arbitarily chosen scale in which the individuals reactions are categorised in relation to one another but not in absolute magnitude. In addition, measures of reactivity are complicated by several factors. Novelty of the test (Kilgour 1975, Soffie & Zayan 1978, Torres-Hernandez & Hohenboken 1979 and Heird, Lennon & Bell 1981), breed differences (Tulloh 1961 and Murphey et al 1980) and age-group differences in investigation (Torres-Hernandez & Hohenboken 1979 and Murphey et al 1981) have been reported to affect measurement of the animals reactivity or temperament. Therefore, although the findings discussed here are of interest their application to other situations or in comparison with other individuals is limited.

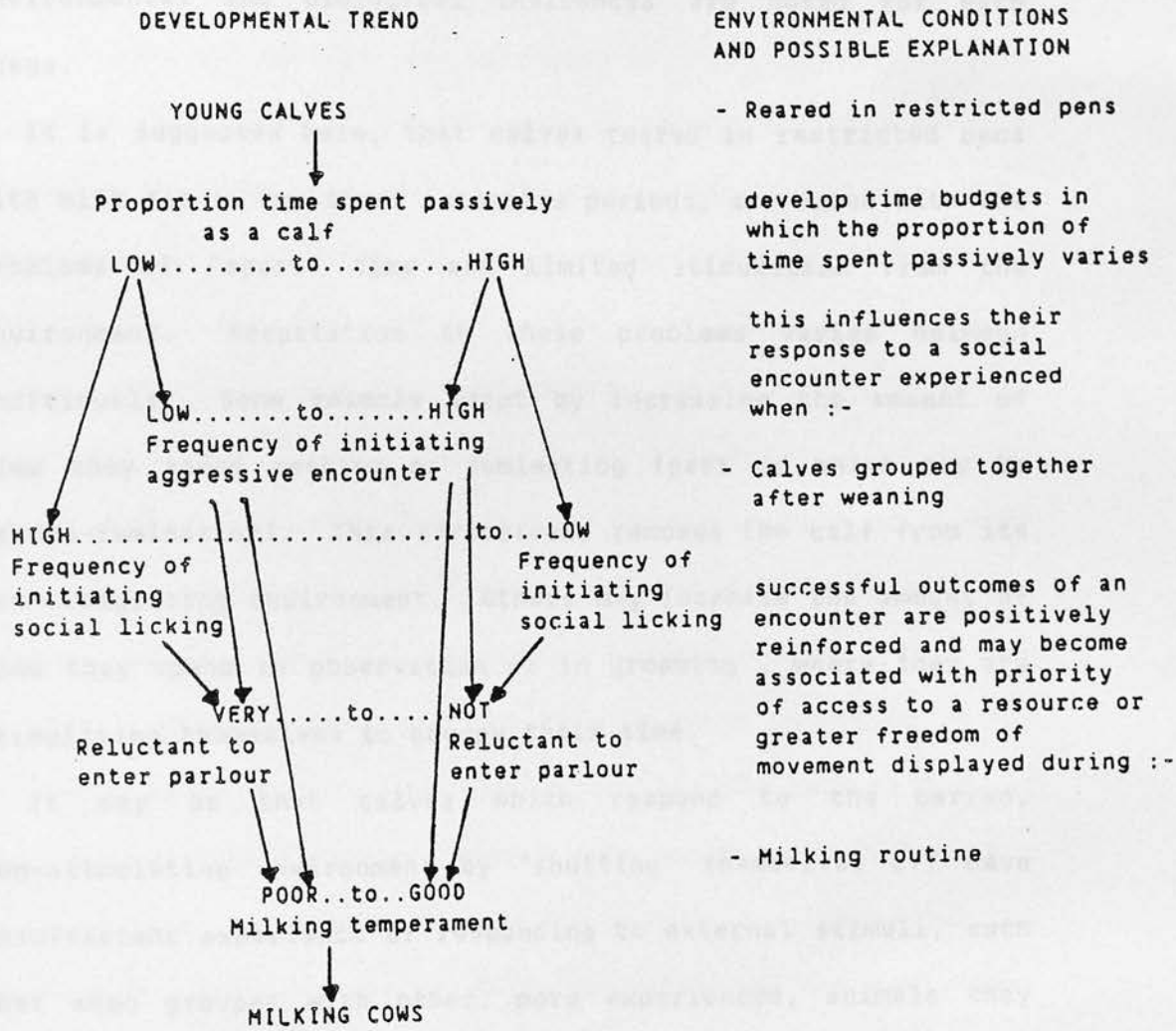
Temperament during milking is of economic importance in dairy cattle. Therefore, any indication of factors which may be associated with it or influence its development would be useful.

For example, the ability to predict the temperament of an individual at some later stage in its development from some measure of its early behaviour could be used in the selection of suitable replacements. This would then save the expense of rearing an individual whose ultimate temperament is likely to cause economic loss e.g. due to increased time spent in the parlour and difficulty in milking causing greater susceptibility to mastitis.

Strelau (1983),in his theory of temperament, suggests that *"an individual at birth has a given temperament which is determined by the physiological mechanisms shaped during prenatal life on the basis of a particular genetic endowment"*. During ontogenesis the individuals temperament may be subject to modification due to maturation and environmental influences. However, a high degree of consistency in the temporal characteristic of temperament has been reported for humans (Thomas & Chess 1977, Leontev 1978 and Strelau 1982). As temperament has been defined as being primarily biologically determined and a result of biological evolution then it should be similar in its characteristics in animals as well as in humans.

These ideas and the results of this study, in particular the investigation of relationships between the various behavioural measurements, led to the hypothesis that the individual behavioural characteristics of a calf are related to its temperament, one expression of which can be recorded during milking. This would then imply that a behavioural

Figure 5.2.1.
HYPOTHETICAL DEVELOPMENT OF BEHAVIOUR CHARACTERISTICS OF DAIRY HEIFERS.



characteristic measured early in a calves development could be used to indicate the likely temperament of the individual at a later stage. This hypothetical trend of development is illustrated in a diagram (Figure 5.2.1.) in which the possible environmental and biological influences are noted for each stage.

It is suggested here, that calves reared in restricted pens with milk fed in two short intensive periods, are faced with the problems of "spare" time and limited stimulation from the environment. Adapatation to these problems varies between individuals. Some animals adapt by increasing the amount of time they spend resting or ruminating (part of which may be psuedo-rumination). This effectively removes the calf from its non-stimulating environment. Others may increase the amount of time thay spend in observation or in grooming , where they are stimulating themselves to occupy their time.

It may be that calves which respond to the barren, non-stimulating environment by "shutting" themselves off have insufficient experience of responding to external stimuli, such that when grouped with other, more experienced, animals they react aggressively in an encounter. Successful outcomes of an encounter are positively reinforced and as most encounters are usually centred around a resource, these may become associated with priority of access to a resorce. Competition for a resource has been used in many studies to assess the hierarchial structure of a group. Several authors found that dominant animals had a greater freedom of movement within the environment

than less dominant animals (Beilharz & Mylrea 1963 and Sato 1982). As these studies usually equate aggression over a resource as dominance, it may be that the more aggressive animals in this study also had a greater freedom of movement within the group. Thus, during the milking routine they also had a greater freedom of movement in the collecting yard allowing them to enter the parlour, which may be regarded as a resource (Whittlestone 1974), freely. These individuals are, therefore, less stressed by the routine of milking than those individuals in the group which are less aggressive. Subsequently, they are less disturbed by the milking process and generally stand quietly resulting in them being classed as having a "good" milking temperament. Those animals which were less aggressive may be disturbed by the more aggressive animals, by contact with the stockman and by forced movement into the parlour. This may result in the animals being unsettled in the parlour causing them to move around, flick their tail or kick at the milking machine or dairyman. This would be regarded as a poor milking temperament as it is likely to result in the individual requiring more time to be milked or the individual being more susceptible to mastitis if the udder in not properly milked.

This scheme would have to be tested with several replicates in different environments to examine its general validity as a scheme for the development of behaviour patterns in bovines.

Nonetheless, it would appear that in general calves which passively occupied their "spare" time were better able to cope

with the initial stress of milking. Of course the explanation is more complex than suggested here as many features, e.g. dairyman's personality (Seabrook 1972), early rearing (Albright 1981), can affect the development of temperament of the individual. The motivation process' involved during the assessment of reactivity to touch and milking temperament could be different in each case emphasising the difficulty in trying to apply measurements of reactivity to other situations. However, an early indication of the temperament an individual is likely to develop, suggested here as the proportion of time a calf spends actively or passively, could therefore be useful in predicting the possible suitability or productivity of the individual. Thus evaluation of the time budgets for a group of calves will indicate those calves which are more likely to develop good milking temperaments. Further, as temperament has been reported to have a moderate to high heritability (O'Bleness, Van Vleck & Henderson 1960, Dickson et al 1970 and Stricklin, Heisler & Wilson 1980), and milking temperament is related to early behaviour, then selection for temperament based on early behaviour may be possible. However, selection for animals which will be easily managed in the parlour does not imply that these animals will be more easily managed overall. These animals may regard the parlour as a resource and are responding to that stimulus, not to stimuli associated with handling.

5.2.4.

RELATIONSHIPS BETWEEN BEHAVIOURAL AND PRODUCTION MEASUREMENTS

The previous section suggested a trend in the development of the behavioural characteristics of an individual. As these are primarily biologically determined it may be expected that there would be a corresponding relationship between the development of these and measures of its biological output i.e. growth rate and mean daily milk yield.

In general, growth rate appreared to be similar for all the heifers with the regression co-efficients of weight gain over the study ranging between 0.619 and 0.771. This was not significantly correlated with any of the behavioural measurements available for the individuals. There was, however, a significant relationship between the frequency of initiating social licking and mean daily yield of the individual ($r = 0.623$, $p < 0.05$).

Although the information available from the literature (see section 2.2.7.) tends to suggest that milking temperament is correlated to productivity, no such relationship was found in this study. However, from the hypothesis suggested previously, good milking temperament would be associated with a low frequency of initiating social licking and, consequently, to a low mean daily milk yield. This is contrary to the information available in the literature where higher milk yields are usually associated with good milking temperaments (e.g. Gupta & Mishra 1974). It is possible that the relationship between the frequency of initiating social licking and milking temperament

is not sufficiently strong enough to infer a relationship between milking temperament and milk yield.

5.2.5. GENERAL DISCUSSION

The main implications of this study, from a developmental point of view, are the discrepancies between the development of behaviour patterns of calves reared intensively and that of calves reared extensively with their dams. Although there are several other variables which may contribute to the variations e.g. breed differences or different weather conditions, the main variable is suggested in this study as being the different rearing conditions, especially the periods of housing, experienced by the dairy calves.

Further research is required on the development of behaviour patterns in calves where social as well as physical factors can be varied. The results of this study suggest that the following aspects should be considered :- stimulation in the pen, natural suckling and rearing in social groups. This may then show specifically, the factors influencing the development of the calves behaviour over the early period of rearing i.e. barrenness of the pen, artificial feeding or lack of social contact or social learning.

Although the relatedness of behavioural activities, suggested in this study, would imply some degree of genetic control, the environmental influence must also be considered important as a change in the early rearing may alter the relationships shown later in development. Changes in the early rearing conditions may be reflected in different adaptations by the individuals and

in different expressions of their behaviour at a later age.

When the results of the study are considered in relation to animal production or husbandry, then it is apparent that the early rearing conditions are not particularly suitable for the rearing of young dairy calves. The results indicate that these calves are abnormal in their behaviour. Although there were no classical stereotypies observed there was sufficient alteration in their time budgets, when compared with naturally reared calves, for their behaviour patterns to be considered abnormal. The lack of external stimulation encourages self-stimulation in the form of grooming or "psuedo-rumination". The calves may also be stressed from a social point of view as they have little or no opportunity to develop stable social relationships due to the continual movement of individuals between groups and groups between different rearing conditions. In mature animals, this instability in group composition has been shown to affect milk production (Brantas 1968 and Brakel & Leis 1976). It is possible that the early experiences of the calves are reflected or associated with problems shown in mature animals such as difficulties in conception, rejection of offspring or difficulties in handling during milking.

In the present economic climate of milk quotas and penalties for over-production in addition to the high cost of skilled labour, a possible alternative to the present methods of rearing dairy calves could be the use of additional cows, or those unsuitable for milking in the parlour because of poor milking temperament or susceptibility to mastitis, for the "foster"

rearing of several calves. This would then allow the calves to feed naturally, develop stable social relationships, and increase the amount of time spent in play activities. Subsequently, the animals would have less "spare" time in which they could develop abnormal behaviour patterns.

5.3. SUMMARY

In summary, the calves of this study generally became more active, increased the time spent ingesting solid food and the time spent ruminating and decreased the time spent resting or sleeping. However, comparison of the actual values of proportion of time spent in particular activities such as ruminating, self-grooming or investigation for the calves in this study with extensively reared calves showed several differences. The intensively reared calves spent a much greater proportion of their time ruminating and grooming themselves and a much lower proportion of their time in investigation than extensively reared calves (Kiley-Worthington & De La Plain 1983 and Wood-Gush *et al* 1985 This was particularly shown during the three rearing periods when the heifers were grouped indoors i.e. calf-house, calves grouped indoors after weaning (CGI) and heifers in yard & cubicles over the winter (HI). It is suggested that the extra time spent ruminating and grooming was an attempt to occupy "spare" time by self stimulation.

Upon grouping after weaning the amount of time spent in investigation increased with a similar increase in social contact, and these then decreased by six months of age to levels similar to that shown by extensively reared calves. Time budgets during the grazing period appeared to be similar for both groups of animals.

Rearing dairy heifers in a yard with *ad libitum* silage and cubicles at approximately one year of age affected their behaviour patterns. They spent a significantly shorter time

eating silage yet increased the amount of time they spent in rumination. As previously suggested this may partly have been "pseudo - rumination" and was performed to occupy "spare" time. The heifers also increased the amount of time they spent standing. A combination of the following suggestions were thought to be the best explanation for this :- 1)disruption of the animals resting by management operations and activity on the farm around them, 2)hyperactive behaviour of heifers in oestrus disrupting the others and 3)heifers unaccustomed to concrete floors, cubicles and slatted passages spend more time standing than lying.

Analysis of behavioural sequences showed that as the animal matured fewer activities were associated in any sequence and that these activities increased in their degree of association. The central activity of investigation (when the heifer was young) changed to movement at about eight months of age. This trend in the development of the context of behavioural activities was similar for both intensively and extensively reared calves.

When considered individually the calves showed variation in their adaptation to the "spare" time they experienced. They also showed differences in the way they responded to a social encounter. Some had a higher frequency of licking than others which tended to respond agonistically. Also the heifers were unable to form stable associations, as found in most extensively reared groups (Rheinhardt & Rheinhardt 1981 and Kiley-Worthington & De La Plain 1983).

The reaction to touch by the heifers was interesting as the majority of heifers consistently reacted, from an early age, by either :- (i)moving away and being difficult to coax to allow touching or (ii)allowing touching. The other measurement of emotionality, milking temperament, was normally distributed and there was little correlation between these two measurements. It is possible that the underlying reasons for each reaction was different. However, investigation of the relationships between all the behavioural measurements showed a significant association between the frequency of initiating aggression and milking temperament. In addition, the correlation coefficients for the realtionships between :- proportion time spent passively as a calf & frequency of initiating aggression, frequency of initiating social licking & proportion times pushed into the parlour and proportion times pushed into the parlour & milking temperament also tended towards significance. This led to the hypothesis of a trend in the development of behaviour characteristics of dairy heifers. This suggested that calves which spent a high proportion of their time passively when reared in a restricted pen tended to react aggressively when grouped with other calves after being weaned. This eventually becomes associated with priority of access to a resource and greater freedom of movement being displayed during the milking routine, such that those animals were not reluctant to enter the parlour and generally developed a good milking temperament.

Investigation of relationships between behavioural and production measurements revealed only a significant relationship

between the frequency an individual initiates social licking and its mean daily milk yield. When considered in relation to the hypothesised trend of development this would suggest that individuals with poor milking temperaments would have a higher milk yield than those with a good milking temperament. This finding is contrary to most of the information available in the literature.

The implications of this study in terms of developmental aspects and application to animal husbandry are discussed. The main points of discussion being :- the differences in the development of behaviour patterns of dairy calves when compared to that expected in calves reared naturally, the factors of the rearing conditions, suggested by the alterations in the calves behavioural development, which may explain the differences, and the suggestion of a possible alternative to the intensive rearing of dairy calves.

5.4. CONCLUSIONS

The following conclusions are drawn from this study :-

1)The periods of housing during the rearing of the dairy heifers in this study influenced the development of their behavioural patterns in that there was a significant increase in the amount of time spent ruminating and self-grooming. This was suggested to occupy "spare" time during this period by self-stimulation.

2)The constant movement of animals between groups and environments appeared to affect their ability to form stable associations between individuals, normally found in stable groups of animals (Reinhardt & Reinhardt 1981).

3)The milking routine appeared to be stressful for those animals which had previously spent more time actively as a calf. Further, most of the heifers in this study tended to enter the parlour within the last third of the milking group, this was also associated with a higher frequency of being pushed into the parlour by the dairyman. It is possible that familiarity with the parlour and milking routine may help the heifers to adapt more quickly to being milked.

4)The individual adaptations by the calves to their restricted environment when in the calf-house appears to be related to other behavioural measurements of their individuality i.e. frequency to initiate social licking or aggression and milking temperament. Thus selection for desired milking temperament by observation of the behaviour of the calf is feasable.

5)In general, it may be better to manage the replacement heifers as one group throughout their life i.e. during rearing and as a milking group. This would facilitate the formation of a stable social group with permanent associations between individuals eliminating the stress which occurs when they are transferred to groups of unfamiliar animals and alleviating the stress associated with movement to an unfamiliar environment.

6)The use of "foster" cows for the rearing of dairy calves may be economically viable in the present economic state. This would then give the calves the opportunity of developing their behaviour patterns in a normal way.

and 7)More information is required on the normal development of behaviour in cattle, particularly between six months of age and maturity. This could then be used to determine the effect of intensive rearing conditions, such as housing over the winter, on the behavioural development of the heifer. Also further work, using a large number of individuals, is required to substantiate the development of relationships between behavioural measurements hypothesised in this study.

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APPENDIX AA

Information relevant to participation.

Figure A1 RECORD TAKEN AT THE BIRTH OF THE CALVES COMPRISING THE STUDY GROUP

COW DATA

General

Cow identification -
Date and Time of Birth of Calf -
Temperature at the birth -

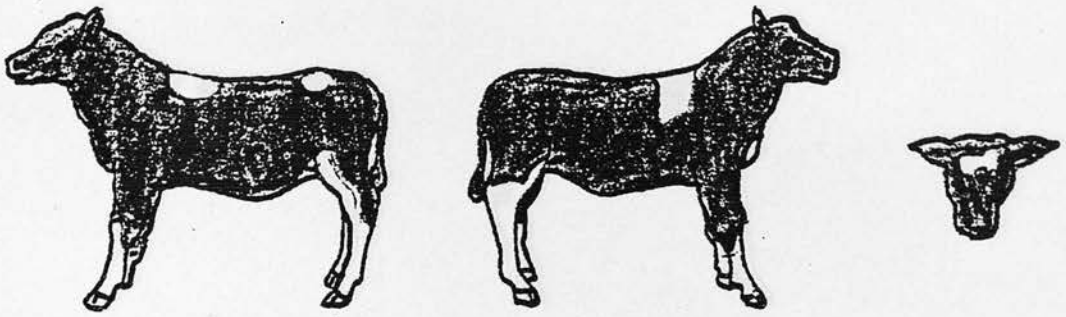
Behavioural

Time cow takes to stand -
Time to lick and clean calf -
Time spent licking calf -
Time spent ignoring calf -
Other observations -

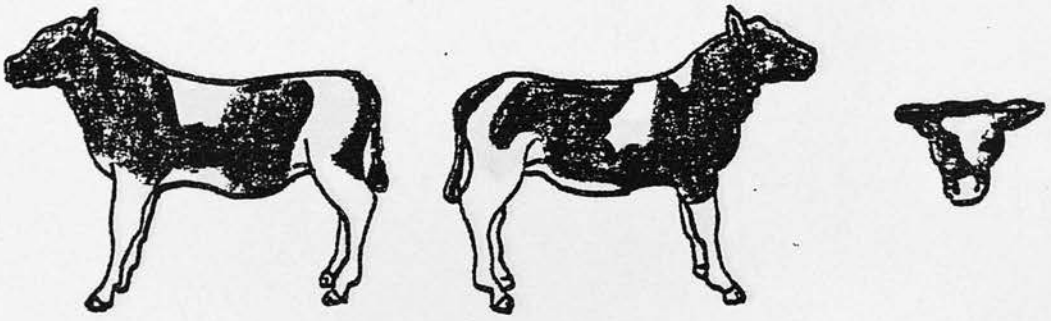
CALF DATA

Calf identification -
Time taken to stand -
Time taken to suckle -
Other observations -

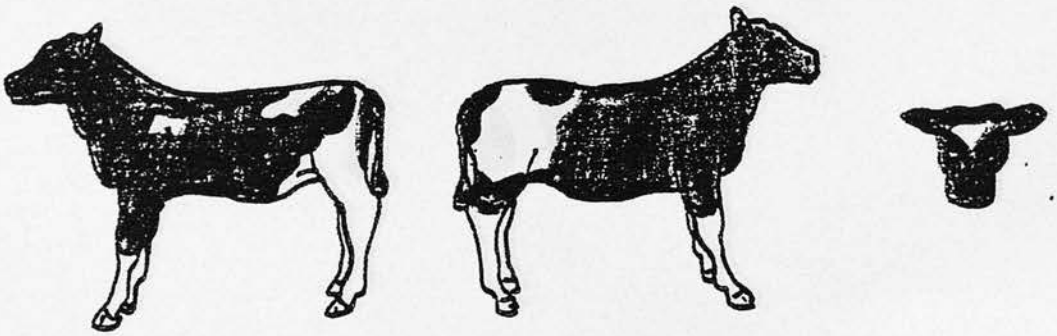
Figure A2 IDENTIFICATION FEATURES OF CALVES IN STUDY GROUP



CALF No. - F130 DATE OF BIRTH - 07-11-81



CALF No. - F131 DATE OF BIRTH - 08-11-81



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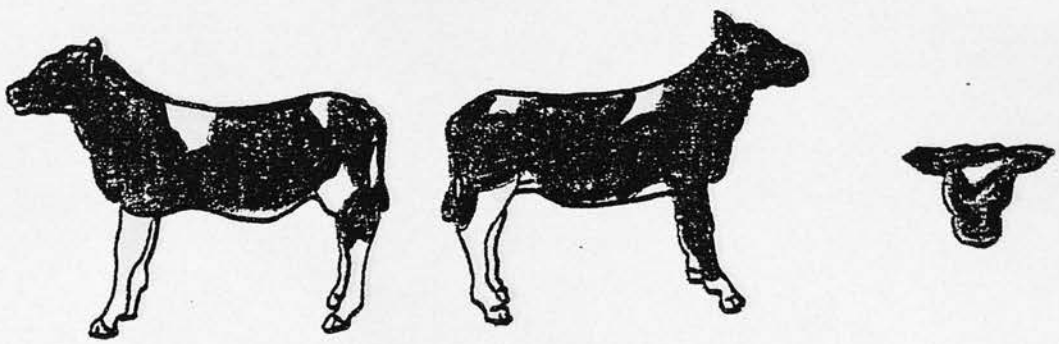

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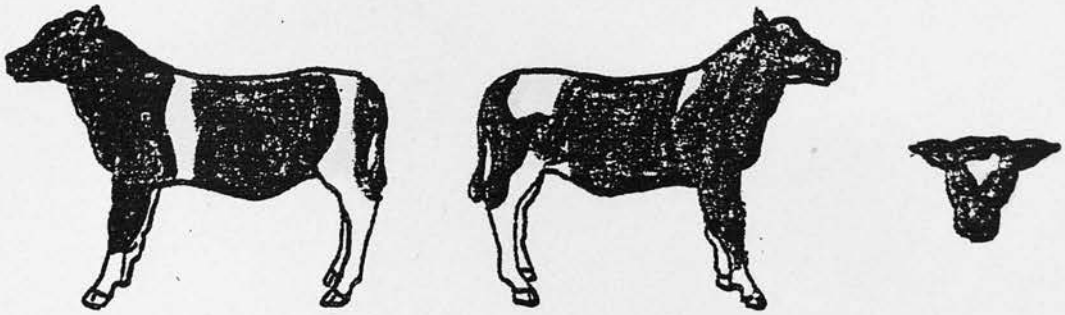
Figure A2 IDENTIFICATION FEATURES OF CALVES IN STUDY GROUP



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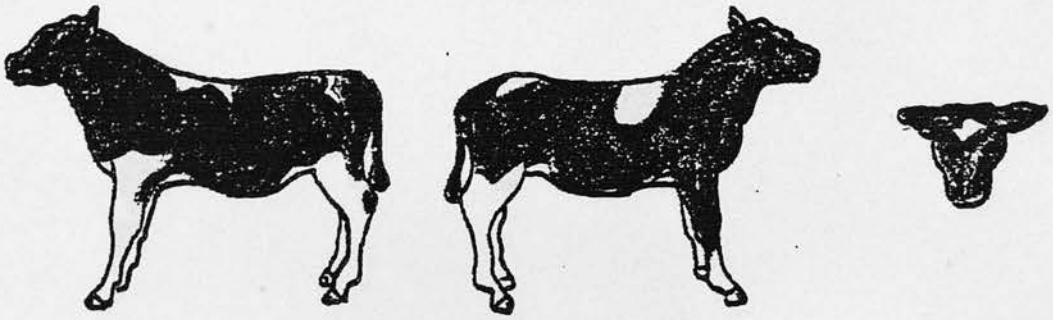
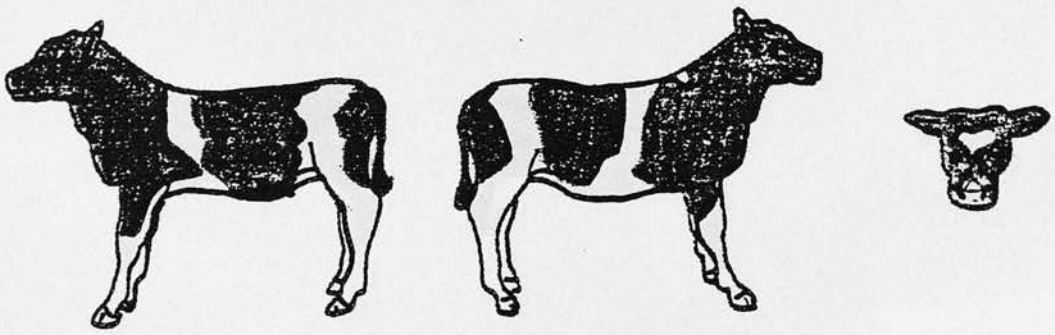


CALF No. - F138 DATE OF BIRTH - 16-11-81



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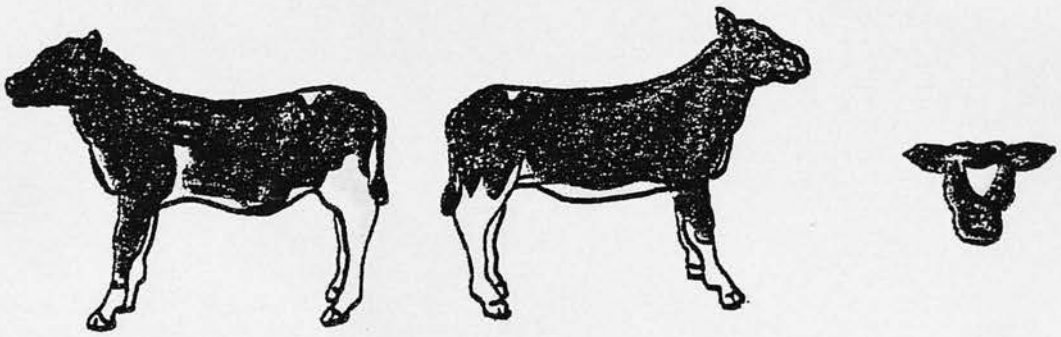
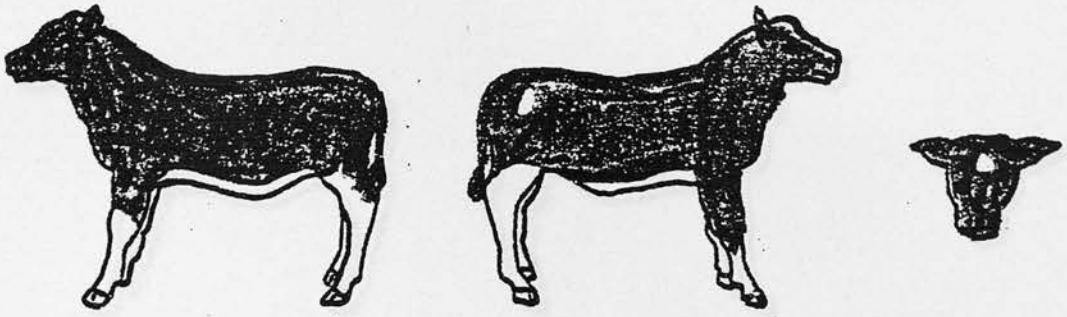


CALF No. - F157 DATE OF BIRTH - 03-12-81

Figure A2 IDENTIFICATION FEATURES OF CALVES IN STUDY GROUP



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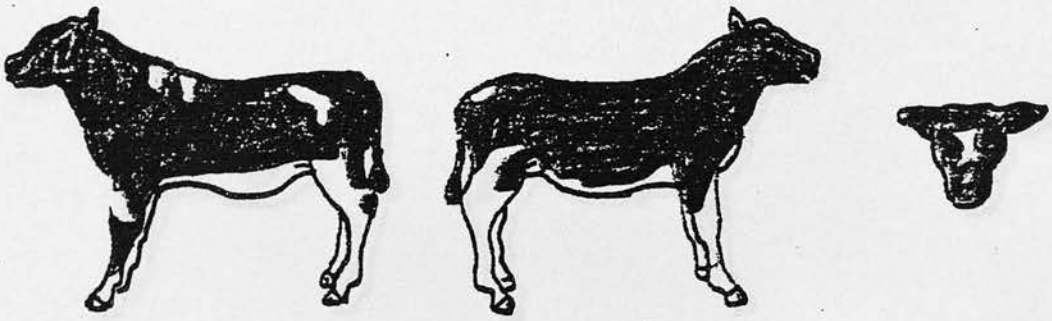

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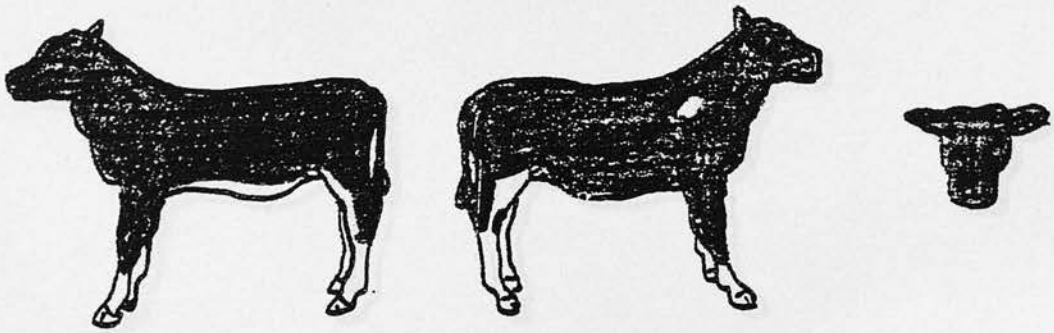
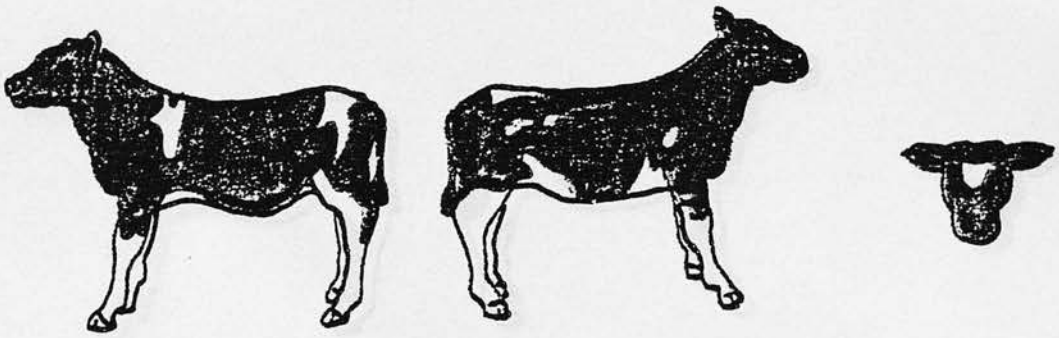
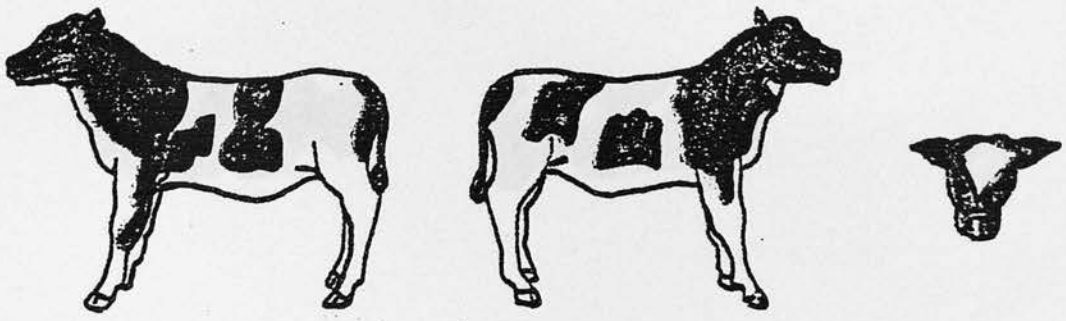


CALF No. - F166 DATE OF BIRTH - 13-12-81

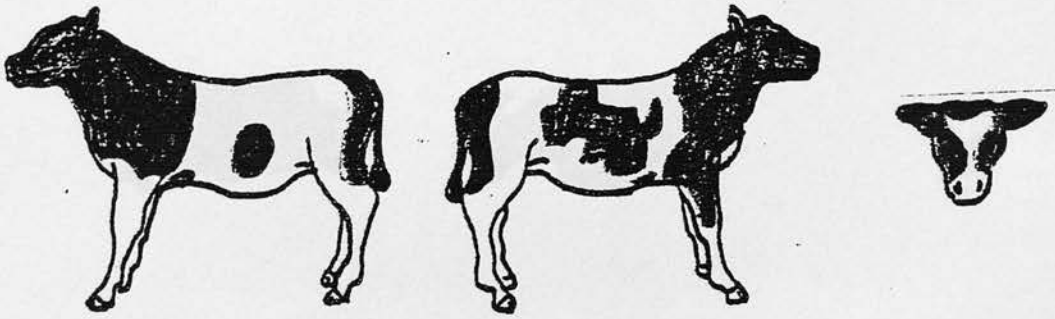


CALF No. - F167 DATE OF BIRTH - 13-12-81

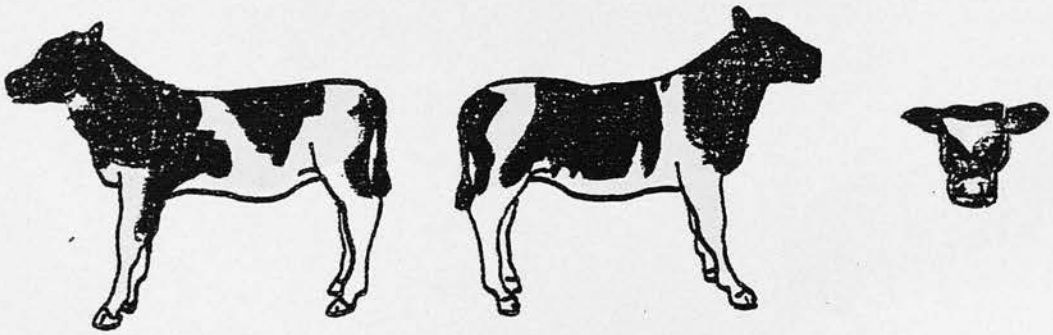
Figure A2 IDENTIFICATION FEATURES OF CALVES IN STUDY GROUP



CALF No. - F168 DATE OF BIRTH - 14-12-81



CALF No. - F169 DATE OF BIRTH - 16-12-81



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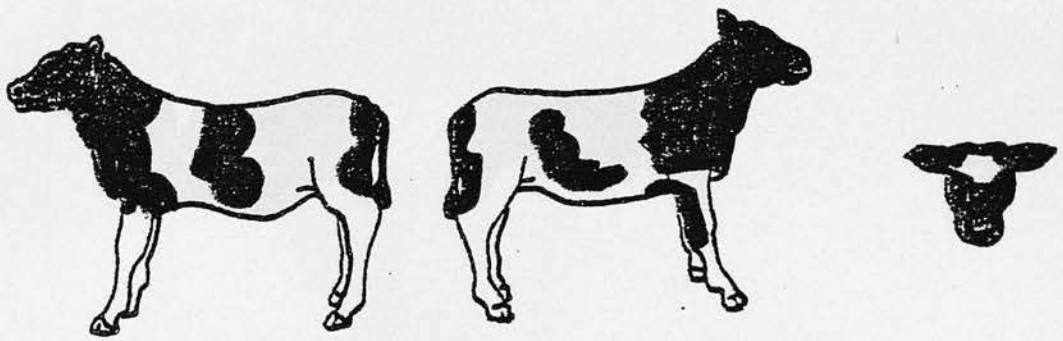
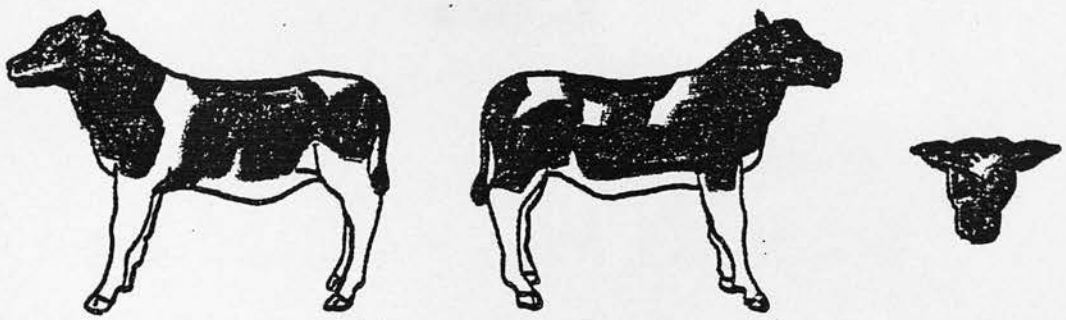


CALF No. - F175 DATE OF BIRTH - 22-12-81

Figure A2 IDENTIFICATION FEATURES OF CALVES IN STUDY GROUP



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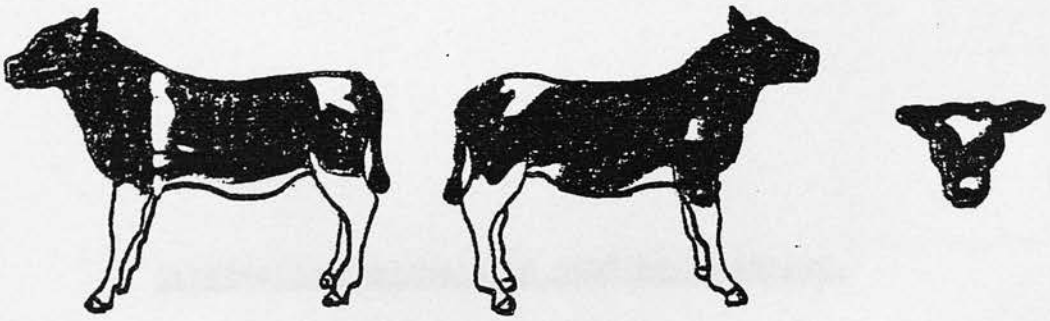
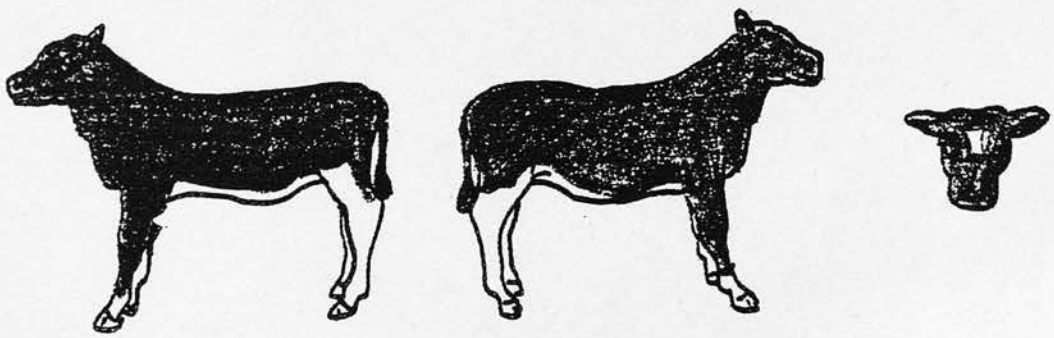
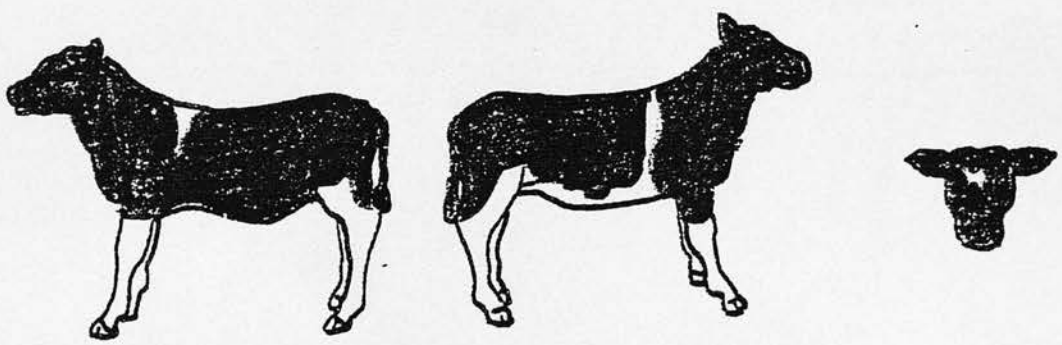


CALF No. - F180 DATE OF BIRTH - 26-12-81



CALF No. - G1 DATE OF BIRTH - 02-01-82

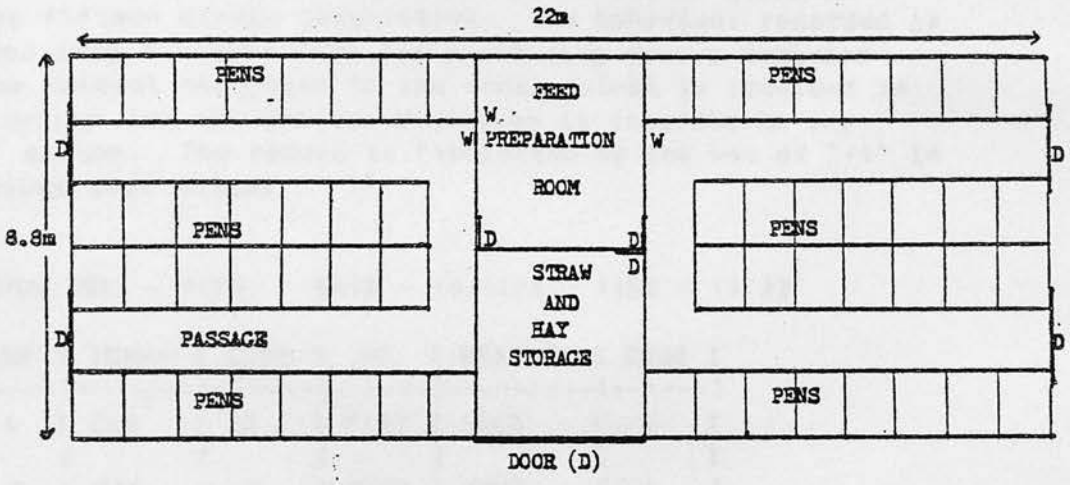


CALF No. - G2 DATE OF BIRTH - 03-01-82

APPENDIX B

Information relevant to calf-house period.

Fig. B1. LAYOUT AND DIMENSIONS OF LANGHILL FARM CALF-HOUSE AND PENS



W - WATER POINTS

PEN

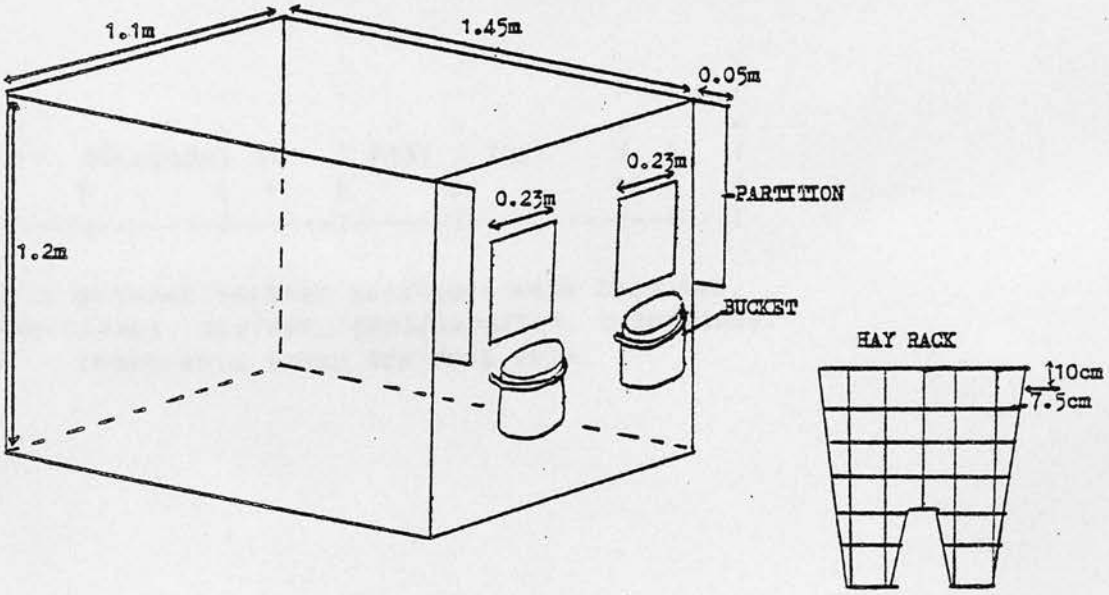


Figure B2 EXAMPLE OF FOCAL ANIMAL RECORD SHEET

This figure shows a typical record taken during a focal animal observation. The time value represents a 30 second interval during the fifteen minute observation. The behaviour recorded is transcribed into a number code for processing onto a computer file. The nearest neighbour to the focal animal is recorded in the "NN" column and the weather condition is recorded in the "weather" column. The record is terminated by the use of "-1" in the behaviour code column.

FOCAL ANIMAL NO. - F166 DATE - 16/12/81 TIME - 11.32

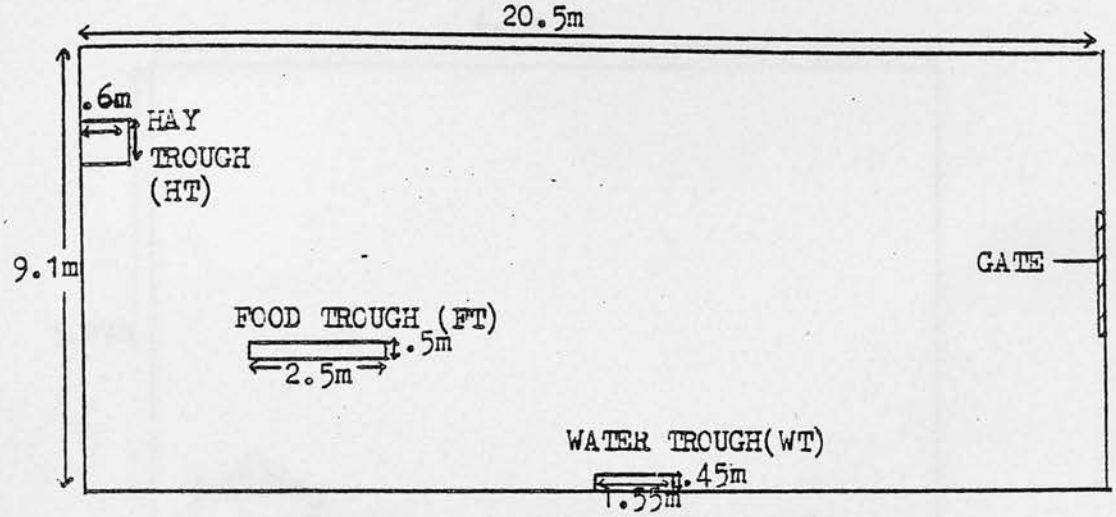
TIME	CODE	BEHAV	CODE	NN	WEATHER	CODE
x x	4	SLA	23	F167	SDCC	4
x x						
	0	VOC	40	F167	SDCC	4
x	1	SLA	23	F167	SDCC	4
		TURN	45	F167	SDCC	4
x x	6	SIg	25	F168	SDCC	4
x x						
x x						
x x	3	SLA	23	F168	SDCC	4
x						
	.	.	.	.	.	.
	.	.	.	.	.	.
	.	.	.	.	.	.
	.	.	.	.	.	.
x	1	SLiSide	31	F131	SDCC	4
			-1			

Note - only general weather coditions were recorded.
e.g. sunny/cloudy, dry/wet, cool/warm/hot, calm/windy.
i.e. SDCC - represents sunny,dry,cool,calm.

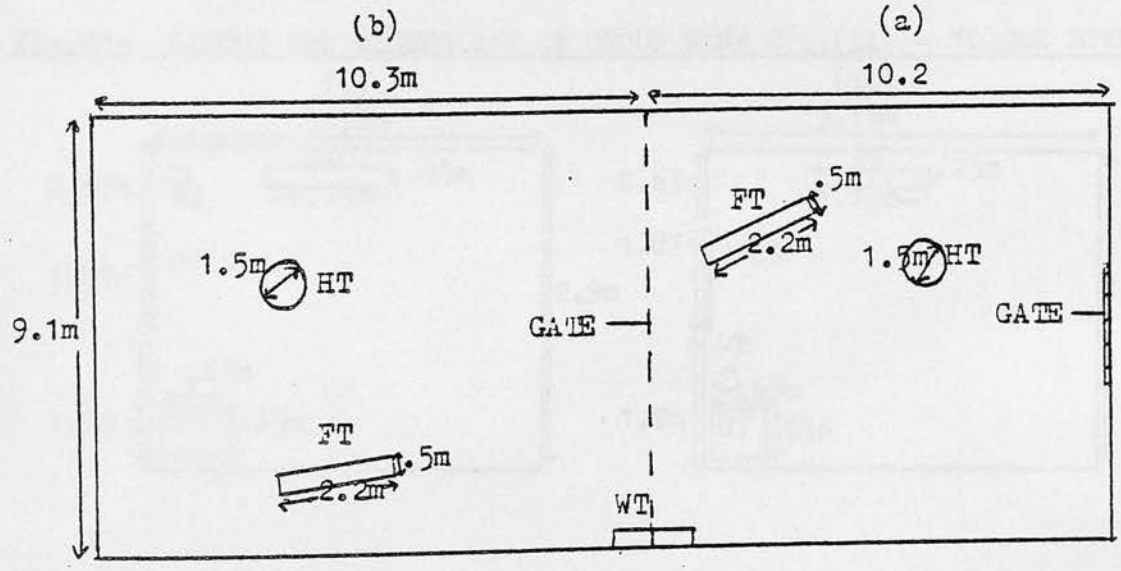
APPENDIX C

Information relevant to weaned calves housed in groups (CGI).

Fig. C1a LAYOUT AND DIMENSIONS OF GROUP PEN A - "BIG BARN"



LAYOUT 23/12/81 - 02/03/82



LAYOUT 02/03/82 - 17/05/82

Fig.C1b LAYOUT AND DIMENSIONS OF GROUP PEN B - "BULL PEN"

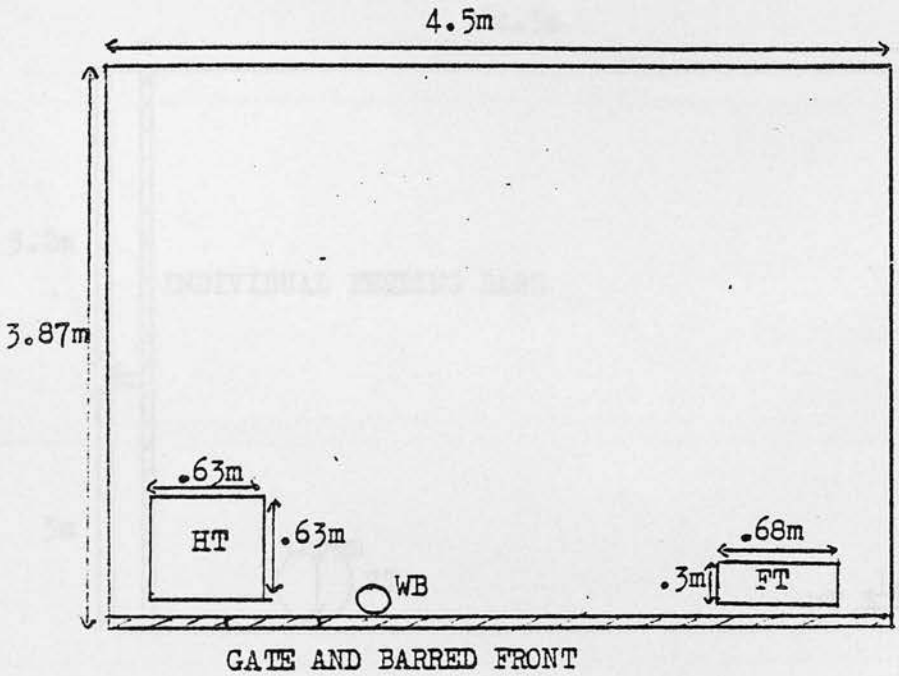
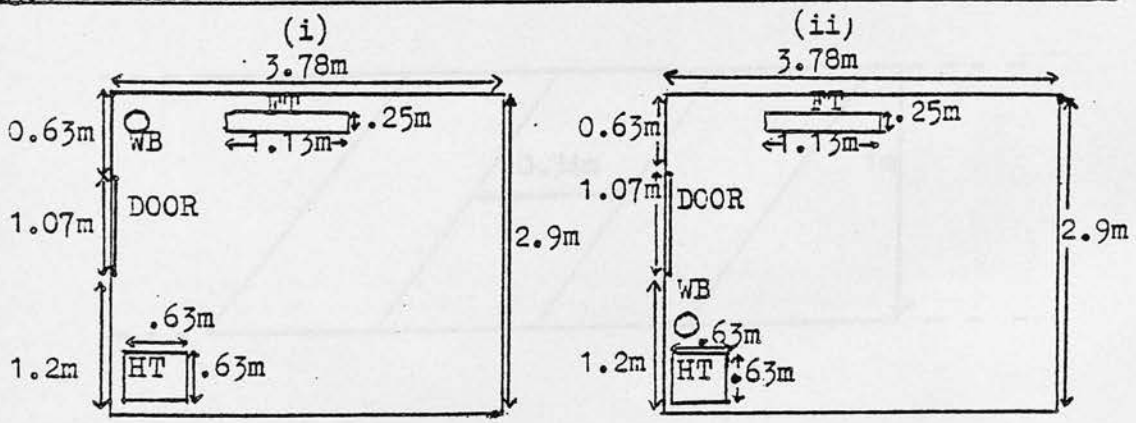


Fig.C1c LAYOUT AND DIMENSIONS OF GROUP PENS C(i)(ii) - "LOOSE BOXES"

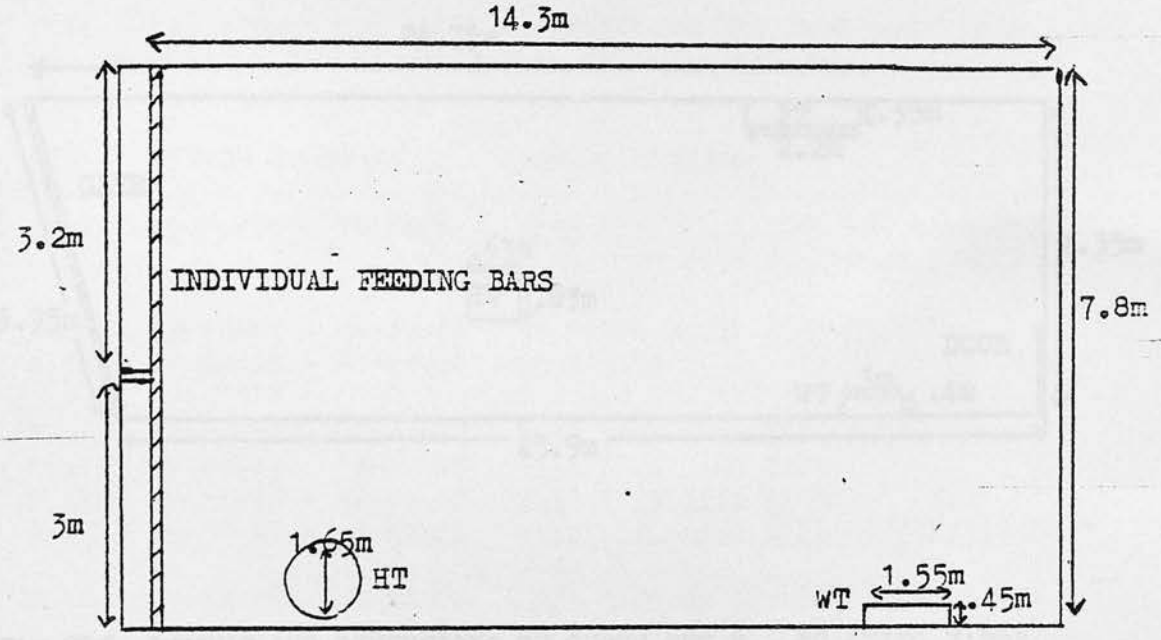


HT - HAY TROUGH

FT - FOOD TROUGH

WB - WATER BUCKET

Fig.C1d LAYOUT AND DIMENSIONS OF GROUP PEN D - "OLD BARN"



INDIVIDUAL FEEDING BARS

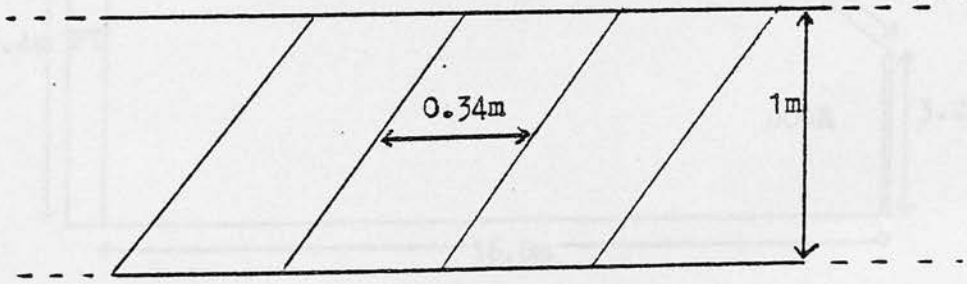


Fig. C1e LAYOUT AND DIMENSIONS OF GROUP PEN E - "LONG BARN"

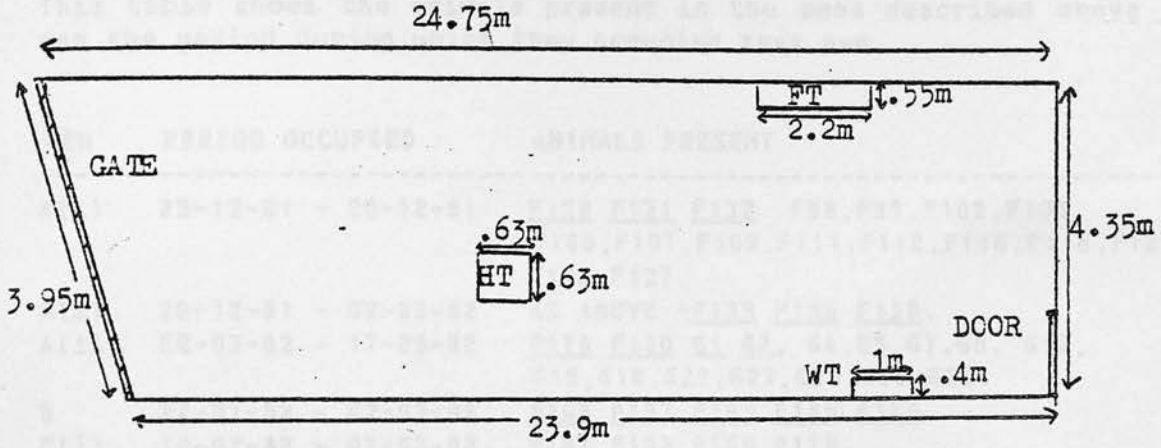
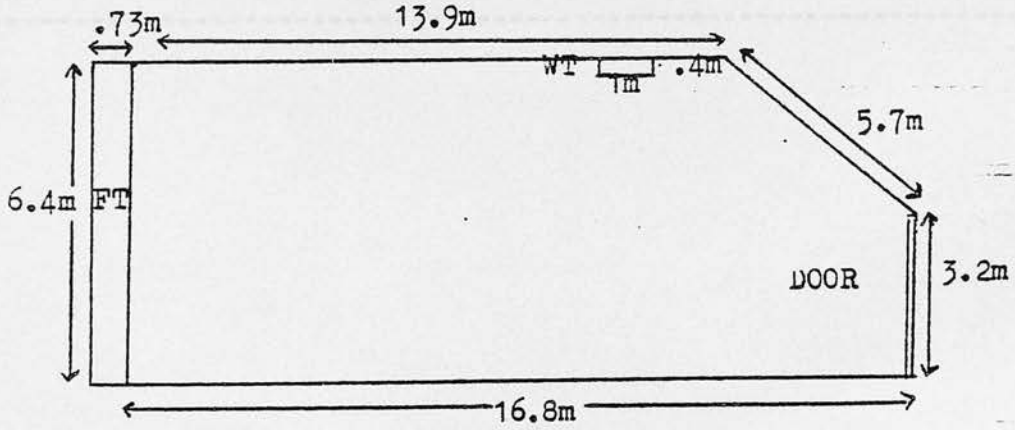


Fig. C1f LAYOUT AND DIMENSIONS OF GROUP PEN F - "CALVING YARD"



NOTE All the pens were straw bedded. Hay or silage was always available. The diagrams shown here are not drawn to scale.

Table C1 COMPOSITION OF THE GROUPS OF CALVES OCCUPYING THE PENS DURING HOUSING AFTER WEANING

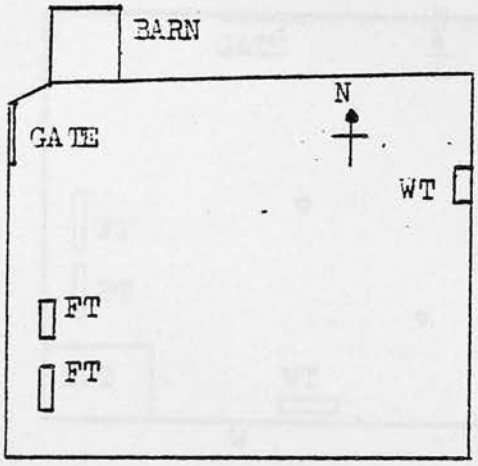
This table shows the animals present in the pens described above and the period during which they occupied that pen.

PEN	PERIOD OCCUPIED	ANIMALS PRESENT
A(i)	23-12-81 - 29-12-81	F130 F131 F132 F98,F99,F102,F105, F106,F107,F109,F111,F112,F116,F118,F120, F123,F127.
A(i)	29-12-81 - 02-03-82	AS ABOVE +F135 F136 F138.
A(ii)	02-03-82 - 17-05-82	F178 F180 G1 G2, G4,G5,G7,G8, G12, G15,G18,G22,G23,G25,G26,G28.
B	22-01-82 - 02-03-82	F143 F157 F163 F165 F166.
C(i)	10-02-82 - 02-03-82	F167 F168 F169 F170.
C(ii)	10-02-82 - 02-03-82	F175 F178 F180 G1 G2.
D	02-02-82 - 13-05-82	F130 F131 F132 F135 F136 F138, F120, F127.
D	17-05-82 - 01-06-82	F178 F180 G1 G2, G4,G5,G7,G8,G18
E	02-03-82 - 13-05-82	F143 F157 F163 F165 F166 F167 F168 F169 F170 F175.
F	13-05-82 - 21-05-82	AS ABOVE + F120.

APPENDIX D

Information relevant to first grazing period (HG1).

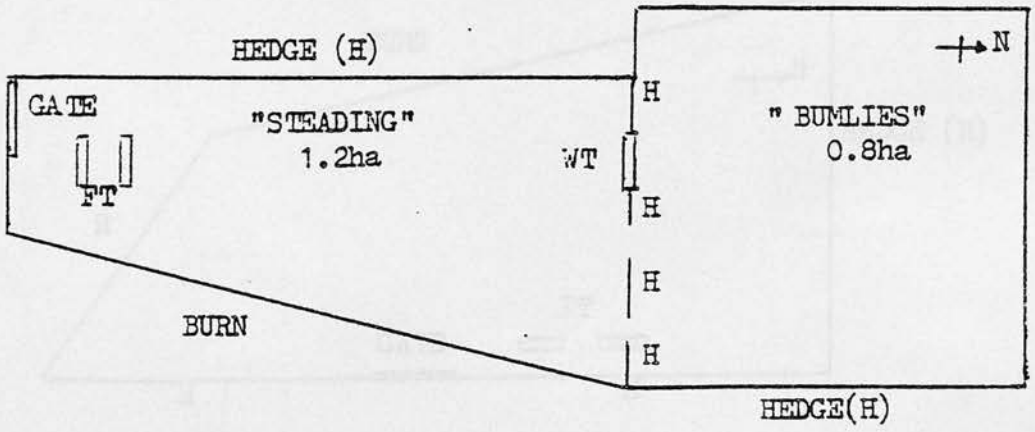
Fig.D1a "TWO - ACRE FIELD" (0.9ha)



PERMANENT PASTURE

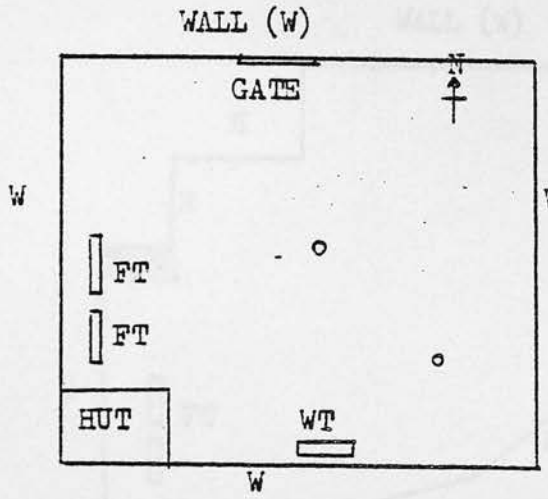
(mixed sward)

Fig.D1b "STEADING AND BUMLIES" (2ha)



PERMANENT PASTURE (mixed sward)

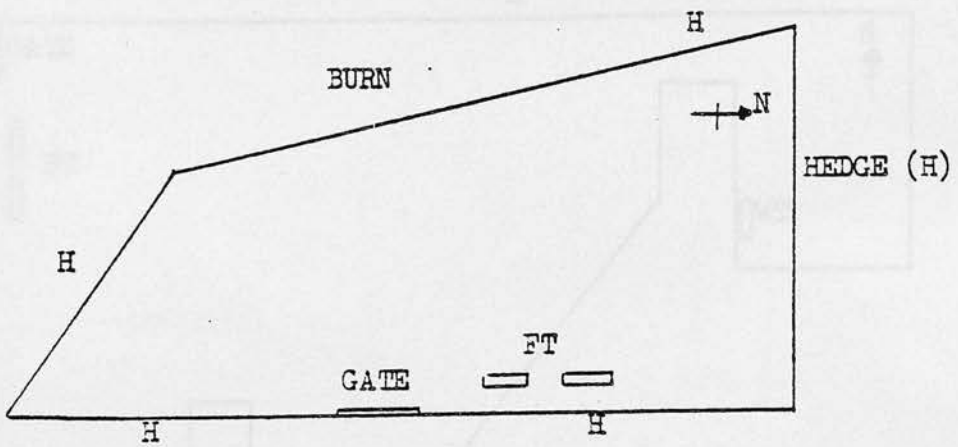
Fig.D1c "DRYMEN GARDEN" (0.9ha)



PERMANENT PASTURE
(mixed sward)

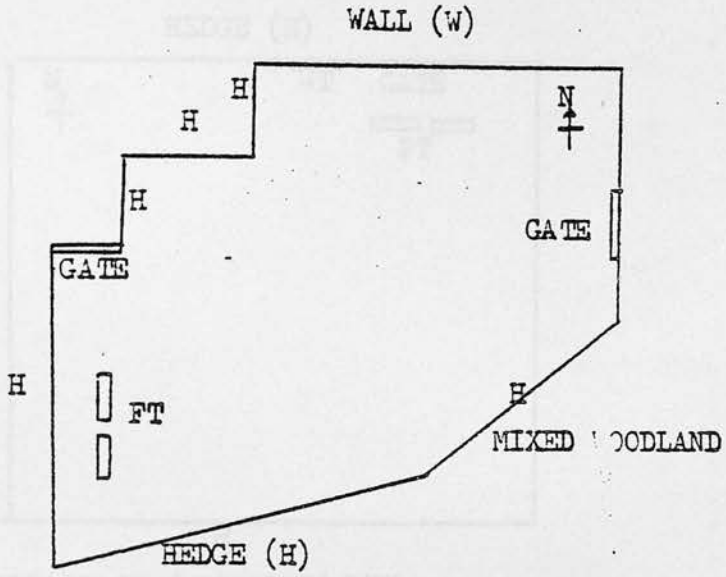
o TELEGRAPH POLES USED FOR RUBBING HEAD AND BODY AGAINST

Fig.D1d "MOAT COTTAGE FIELD" (1.2ha)



PERMANENT PASTURE (mixed sward)

Fig.D1e "GARDEN COTTAGE" (1.0ha)



PERMANENT PASTURE (mixed sward)

Fig.D1f "POULTRY RESEARCH CENTRE" (4.25ha)

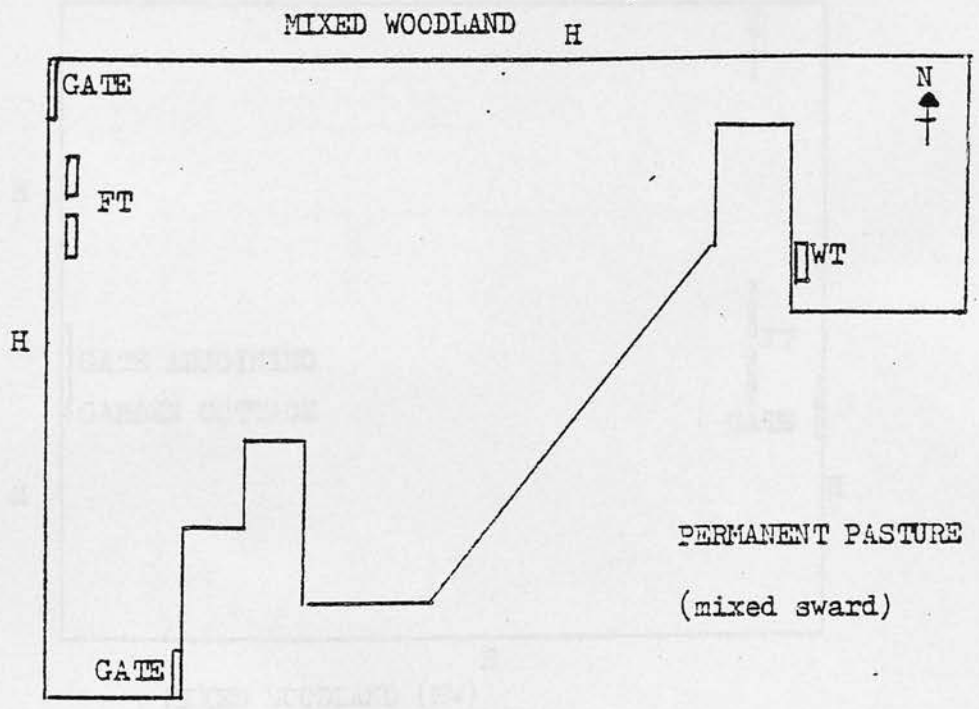
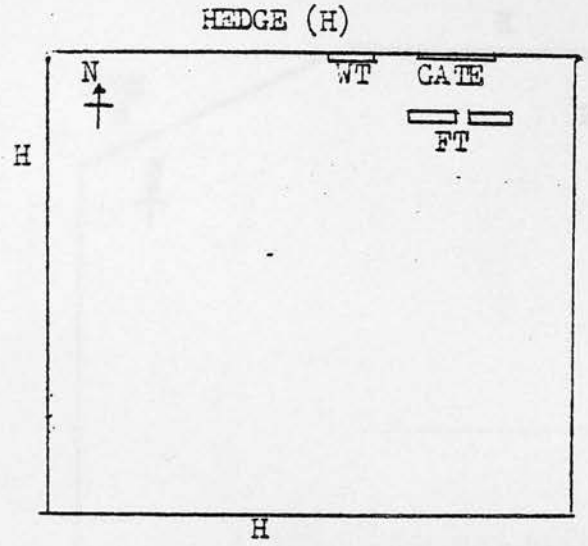
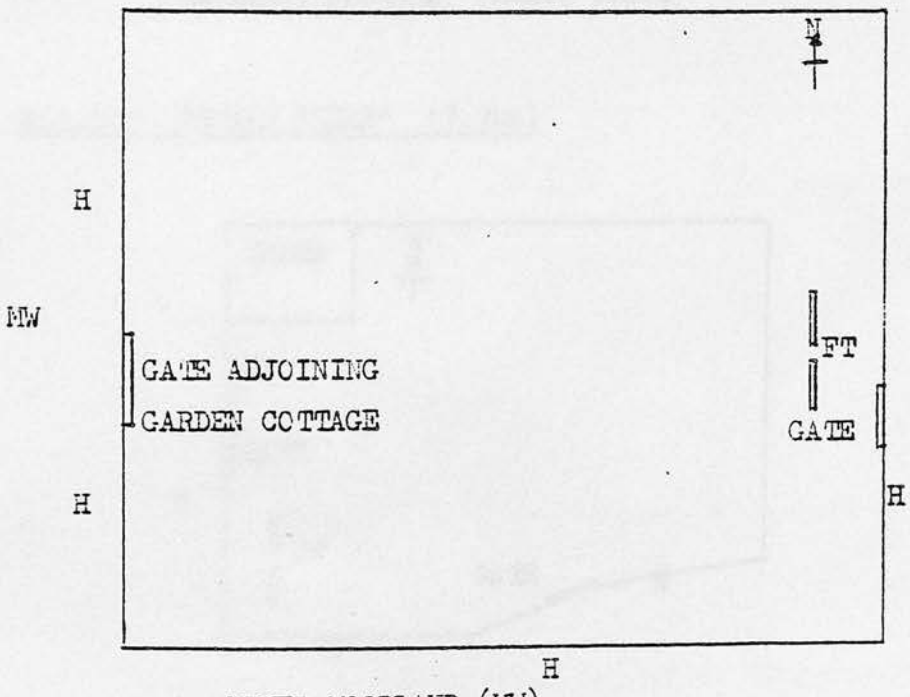


Fig.D1g "SCUTH ROAD" (2.8ha)



RYE GRASS / AGROSTIS LEY

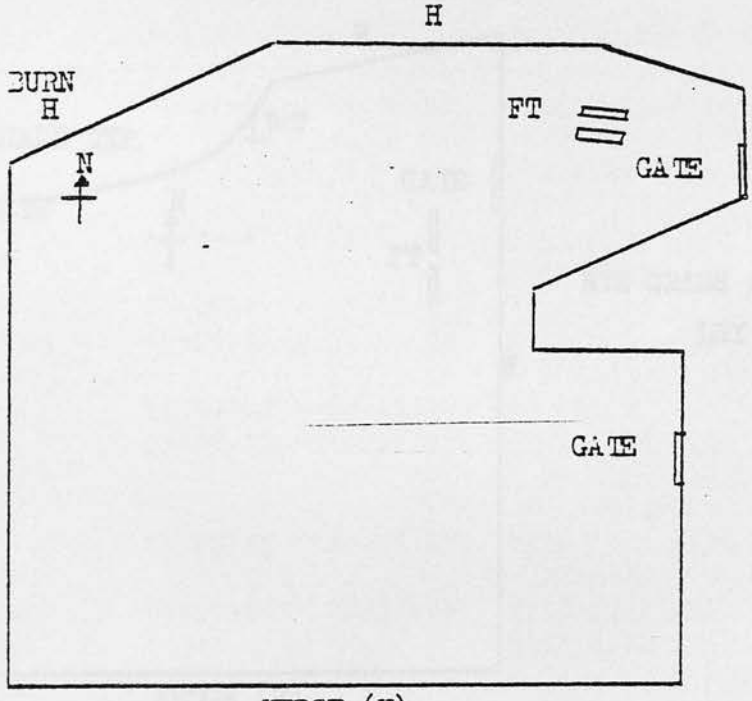
Fig.D1h "DRYMEN AND COTTAGE GARDEN" (total of 7.4ha)



MIXED WOODLAND (MW)

PERMANENT PASTURE (mixed sward)

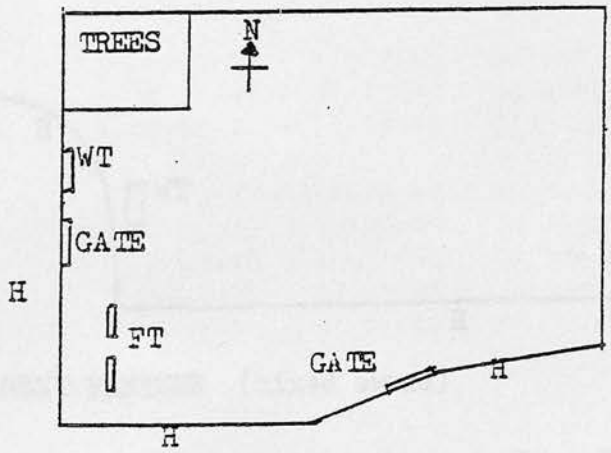
Fig.D1i "ANNIES KNOWE FIELD" (6.0ha)



HEDGE (H)
MIXED WOODLAND

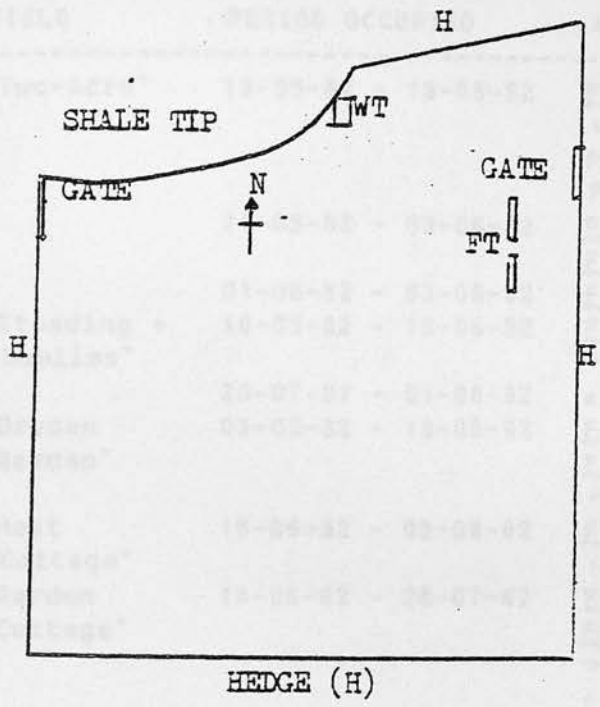
PERMANENT PASTURE (mixed sward)

Fig.D1j "HOUSE FIELD" (3.2ha)



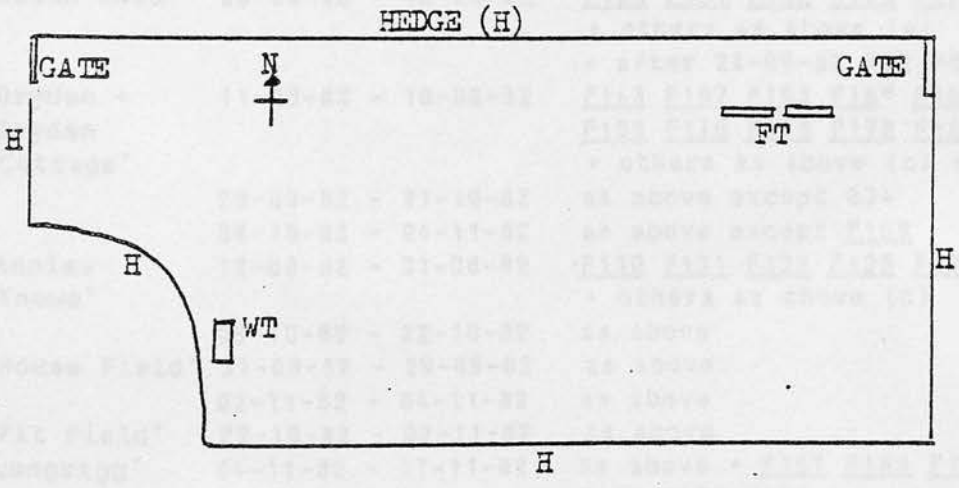
PERMANENT PASTURE (mixed sward)

Fig.D1k "PIT FIELD" (5.3ha)



RYE GRASS / AGROSTIS LEY

Fig.D1l "LONGRIGG" (6.5ha)



PERMANENT PASTURE (mixed sward)

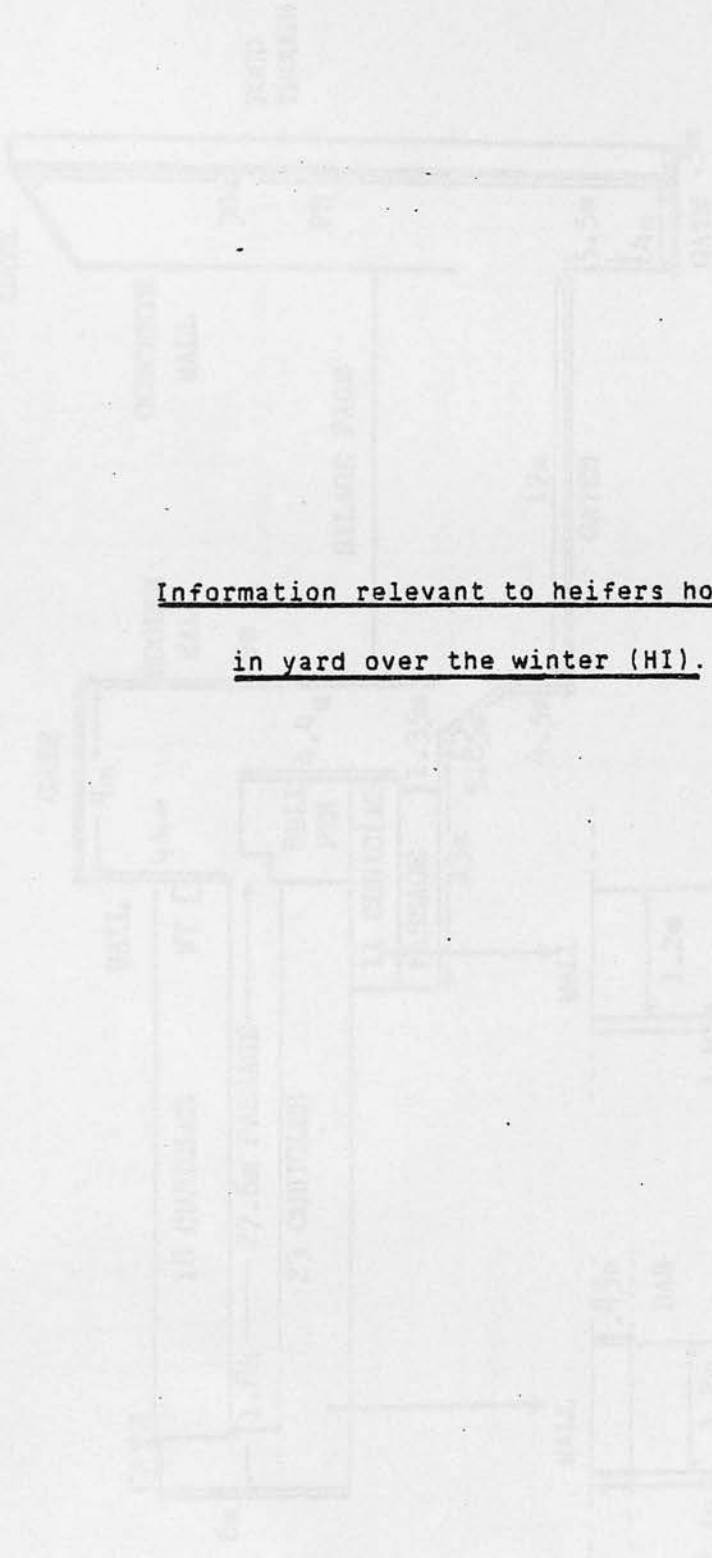
NOTE Prevailing winds were south westerly. Permanent pasture usually comprised of :- festuca, agrostis, poa, dactylis, phleum, lolium and clover mixed sward. Hedges were usually hawthorn.

Table D1 COMPOSITION OF THE GROUPS OF CALVES OCCUPYING THE VARIOUS FIELDS DURING THE FIRST GRAZING PERIOD

This table shows the animals present in the fields described above and the period during which they were in that field.

FIELD	PERIOD OCCUPIED	ANIMALS PRESENT
"Two-Acre"	13-05-82 - 18-05-82	F130 F131 F132 F135 F136 F138, +F79,F81,F87,F88,F90,F92,F96,F98, F99,F102,F105,F106,F107,F109,F111, F112,F116,F118,F122,F123,F127 (a)
	21-05-82 - 03-06-82	F143 F157 F163 F165 F166 F167 F168 F169 F170 F175 + F120
	01-06-82 - 03-06-82	F178 F180 G1 G2, + G4,G5,G7,G8,G18
"Steading + Bumlies"	18-05-82 - 15-06-82	F130 F131 F132 F135 F136 F138, + others as above (a)
	20-07-82 - 03-08-82	as above
"Dryden Garden"	03-06-82 - 18-06-82	F143 F157 F163 F165 F166 F167 F168 F169 F170 F175 F178 F180 G1 G2 +F120,G4,G5,G7,G8,G18 (b)
"Moat Cottage"	15-06-82 - 03-08-82	F130 F131 F132 F135 F136 F138 + others as above (a)
"Garden Cottage"	18-06-82 - 28-07-82	F143 F157 F163 F165 F166 F167 F168 F169 F170 F175 F178 F180 G1 G2 + others as above (b) + after 10-07-82, G12,G15,G23,G25, G26,G28,G34,G35,G36,G37,G41,G43,G49(c)
"Poultry Research"	28-07-82 - 11-08-82	as above
	10-09-82 - 29-09-82	as above except G34 + G4
	21-10-82 - 28-10-82	as above except F169
"South Road"	03-08-82 - 12-08-82	F130 F131 F132 F135 F136 F138 + others as above (a) + after 24-09-82 F62,F66,F67,F73(d)
"Dryden + Dryden Cottage"	11-08-82 - 10-09-82	F143 F157 F163 F165 F166 F167 F168 F169 F170 F175 F178 F180 G1 G2 + others as above (c) except G4
	29-09-82 - 21-10-82	as above except G34
	28-10-82 - 04-11-82	as above except F169
"Annies Knowe"	12-08-82 - 31-08-82	F130 F131 F132 F135 F136 F138 + others as above (d)
	09-10-82 - 22-10-82	as above
"House Field"	31-08-82 - 29-09-82	as above
	02-11-82 - 04-11-82	as above
"Pit Field"	22-10-82 - 02-11-82	as above
"Longrigg"	04-11-82 - 17-11-82	as above + F157 F163 F165 F166 F167 F168 F170 F175

APPENDIX E



Information relevant to heifers housed in yard over the winter (HI).

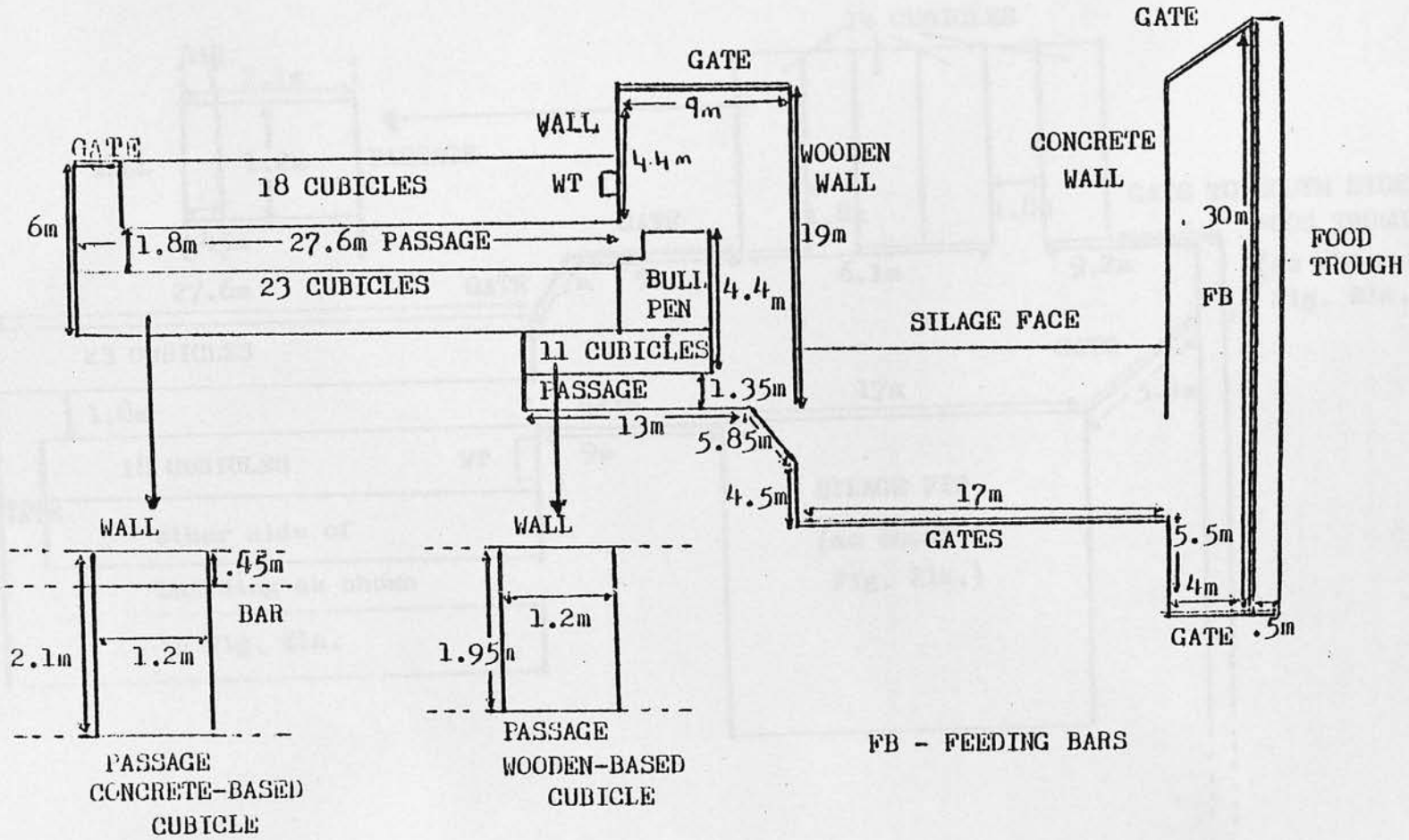


Figure E1a. YARD AND CUBICLES

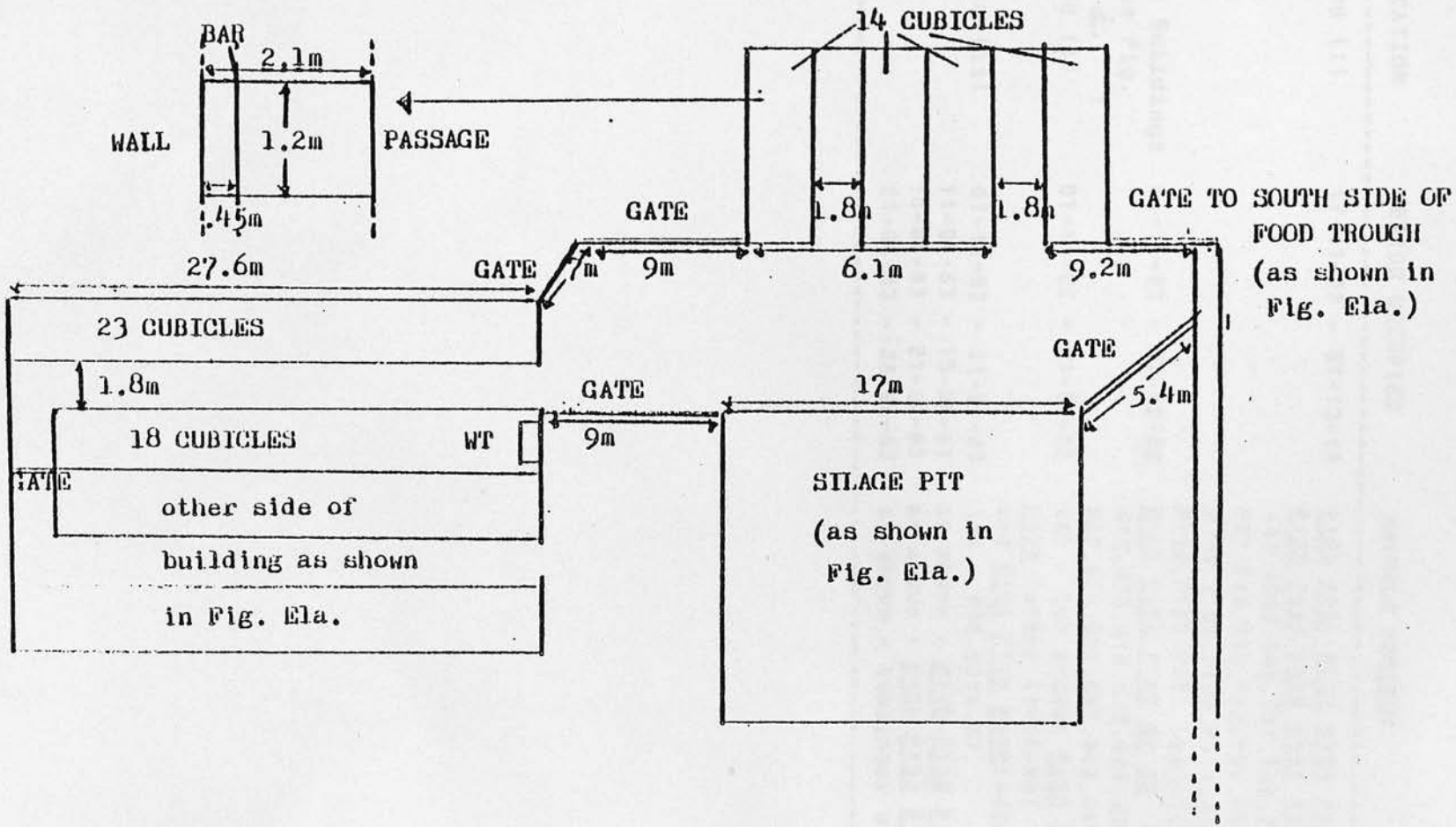


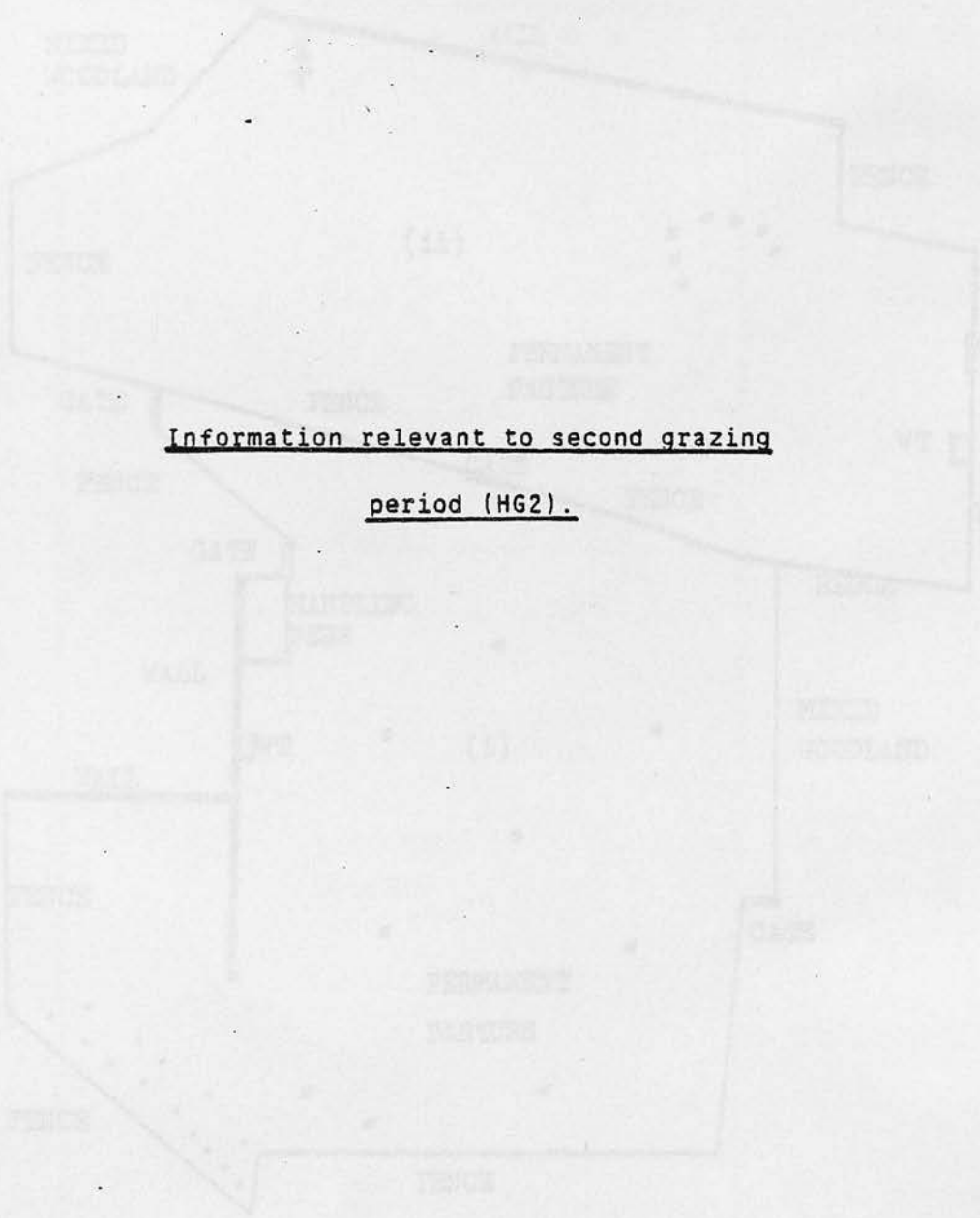
Figure E1b. YARD AND CUBICLES

Table E1 COMPOSITION OF GROUPS DURING SECOND HOUSING PERIOD

This table shows the animals present in the two yard sections described above during housing over the winter.

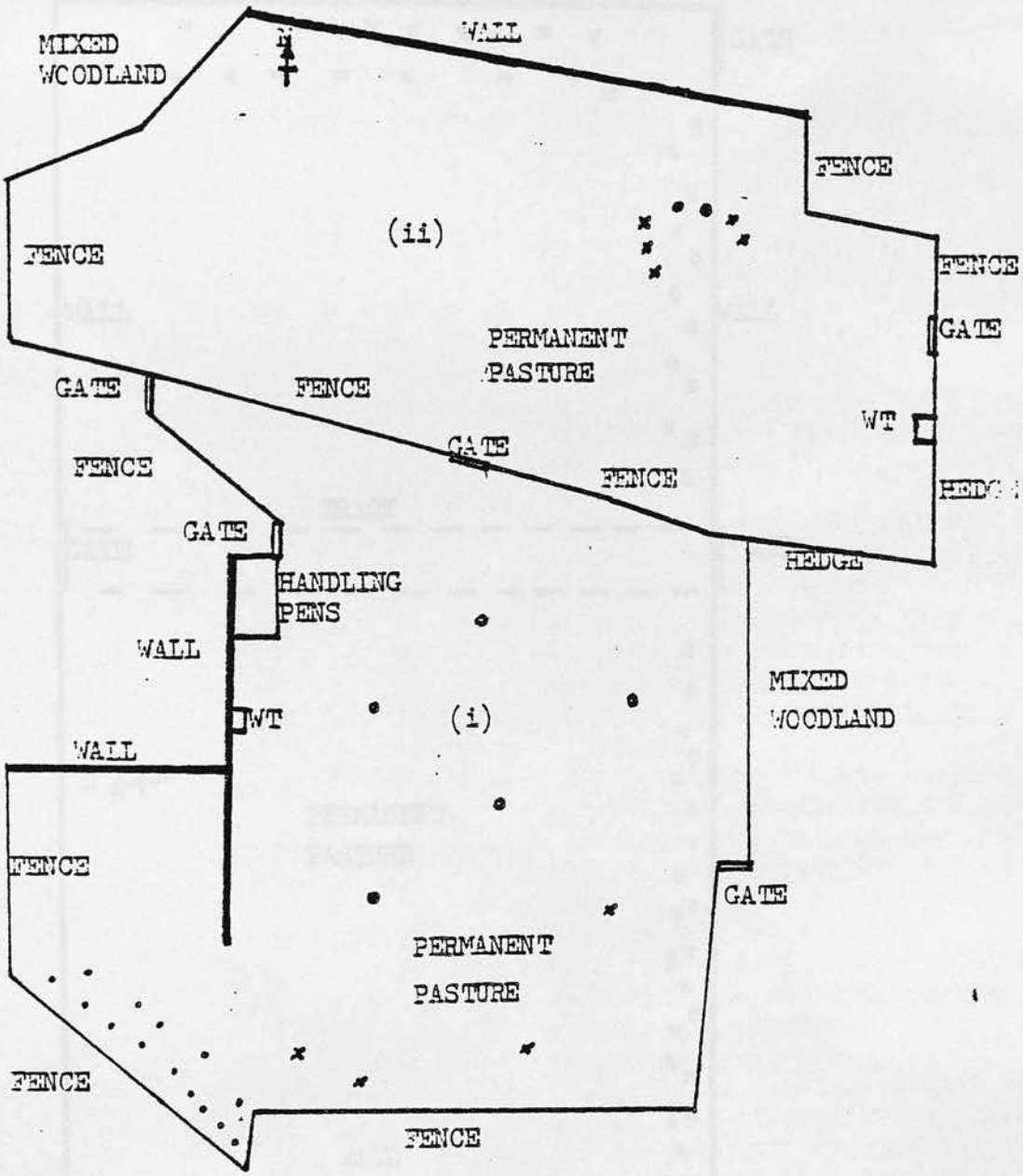
LOCATION	PERIOD OCCUPIED	ANIMALS PRESENT
Yard (i)	17-11-82 - 07-12-82	F130 F131 F132 F135 F136 F138 F157 F163 F165 F166 F167 F168 F170 F175 (a) +F62,F66,F67,F69,F73,F79,F82, F87,F88,F90,F92,F96,F98,F102,F105, F106,F107,F109,F111,F112,F116,F118, F122,F123,F127 (b)
Old Buildings (see Fig. C1d.)	04-11-82 - 07-12-82	F143 F178 F180 G1 G2 + G5,G7,G8, G12,G15,G18,G22,G23,G25,G26,G28, G35,G36,G37,G41,G43,G46 (c)
Yard (i)	07-12-82 - 21-04-83	(a) + (c) except F130 F136 F138 F143 (after 11-04-83) and F131 F132 F135(after 15-04-83)
Yard (ii)	07-12-82 - 11-04-83	(b) + F35,E114,87
	11-04-83 - 15-04-83	as above + F130 F136 F143 F138
	15-04-83 - 21-04-83	as above + F131 F132 F135
	21-04-83 - 26-04-83	as above + remainder of (a) + (c)

APPENDIX F



Information relevant to second grazing period (HG2).

Figure F1a MORTONHALL (i)-6.0 ha (ii)-6.0 ha



NOTE - permanent pasture usually comprised of :- festuca, agrostis, poa, dactylis, phleum, lolium and clover mixed sward. Prevailing winds were south westerly.

KEY - x - Sycamore, o - Horse Chestnut, • - Pine

WT - water trough

Figure F1b FAIRMILEHEAD (6.0 ha)

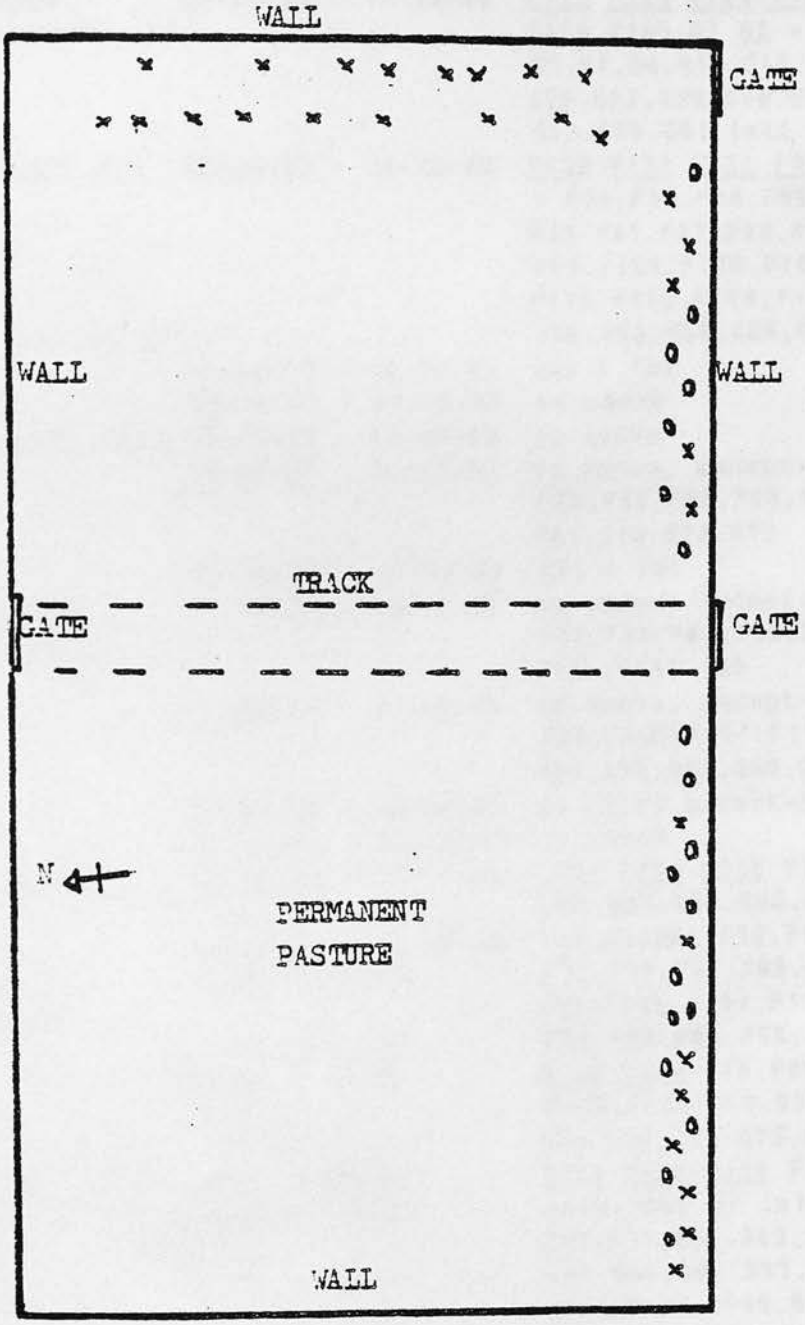


Table F1 COMPOSITION OF GROUPS OCCUPYING THE VARIOUS FIELDS DURING THE SECOND GRAZING PERIOD

This table shows the animals present in the fields described above and the period during which they were in that field.

FIELD	PERIOD OCCUPIED	ANIMALS PRESENT
"Two-Acre" (see Appendix D)	26-04-83 - 12-05-83	F135 F165 F166 F167 F168 F170 F175 F178 F180 G1 G2 + B7,E42,E114,F62, G5,G7,G8,G12,G15,G18,G22,G23,G25, G26,G28,G35,G36,G37,G41,G43,G49, G50,G52,G61 (all a)
Mortonhall (i)	26-04-83 - 12-05-83	F130 F131 F132 F136 F138 F143 F157 + F50,F52,F58,F59,F65,F66,F67,F69, F79,F81,F87,F88,F90,F92,F96,F98, F99,F102,F105,F106,F107,F109,F111, F112,F116,F118,F120,F123,F127,G55, G56,G58,G60,G66,G72,G73 (all b)
	14-06-83 - 10-07-83	(a) + (b)
	21-07-83 - 01-08-83	as above
Mortonhall (ii)	12-05-83 - 14-06-83	as above
	10-07-83 - 21-07-83	as above, except- F131 F132 F166 F79,F87,F88,F90,F99,F106,G55,G58,G60, G61,G70,G72,G73
	01-08-83 - 11-08-83	(a) + (b)
Mortonhall (i + ii)	11-08-83 - 20-08-83	as above, except- F52,F59,F67,F69, F72,F81,F87,F88,F90,F92,F106,F109, F112,F116 (c)
	14-09-83 - 21-09-83	as above, except- F130 F143 F79, F99,F105,F107,F111,F120,F123,G50,G52, G55,G56,G58,G60,G61,G66,G70,G72,G73
	21-09-83 - 22-09-83	as above,except-F131 F136 F138 F122
	22-09-83 - 05-10-83	as above
Fairmilehead	10-07-83 - 21-07-83	F131 F132 F166 F79,F87,F92,F99,F106, G55,G56,G58,G60,G61,G66,G70,G72,G73
	20-08-83 - 14-09-83	(c) except-F50,F58,F65,F98,F102
Langhill (or sold)	from 11-08-83	F52,F59,F67,F69,F72,F81,F87,F88, F90,F106,F109,F112,F116
	from 20-08-83	F50,F58,F65,F98,F102
	from 14-09-83	F130 F143 F79,F99,F105,F107,F111, F120,F123,G50,G52,G55,G56,G58,G60, G61,G66,G70,G72,G73
	from 21-09-83	F131 F136 F138 F122
	from 01-10-83	remainder of (a)+(b) +B7,B15,B25, B29,B31,B34,B43,B65,B71,B72,B78, B82,B84,B89,B93,B94,B106,B113,B116, B120,B125,B165,B184,B185,B187,B199, B214,E42,E108,E109,E145,E158,E164

NOTE - B7-bull, other B-letters are freeze-branded cows,
E-letters are heifers born in 1980,
F-letters are heifers born in 1981,
G-letters are heifers born in 1982.

APPENDIX G

Information relevant to calving and incorporation into the milking herd.

Table G1 CALVING DATES OF HEIFERS OF STUDY GROUP

This table shows the dates of calving of those heifers of the study group which calved at Langhill farm. Those not shown were sold before calving.

HEIFER	CALVING DATE
F130	27-10-83
F132	19-11-83
F135	28-03-84
F136	25-10-83
F138	13-11-83
F143	01-11-83
F157	07-12-83
F163	11-12-83
F165	25-03-84
F166	04-12-83
F167	19-12-83
F168	29-12-83
F170	08-12-83
F175	13-12-83
F180	14-12-83

Figure G1 EXAMPLE OF RECORD TAKEN DURING MILKING

FOR ASSESSMENT OF TEMPERAMENT

COW NO. - DATE - Morning/Afternoon

ENTRY TO PARLOUR

POSITION - within first third of milking group --------
within middle third of milking group --------
within last third of milking group --------

BEHAVIOUR - walks forward into parlour --------
pushed into parlour by dairyman --------

IN PARLOUR

DURING PREPARATION -

1) moves around uneasily (from foot to foot, not due to injury) --------
stands and eats contentedly --------

2) allows handling during washing etc. --------
becomes agitated - moves around in stall, may kick --------
stands still but flicks tail often --------

DURING MILKING -

3) stands contentedly (may be eating, cudding, or looking around) --------
moves around in stall --------
other activity (e.g. licking wall or tail switching) --------

APPENDIX H

Data relevant to analysis of general development of behavioural patterns.

Table H1 TOTAL HOURS OF OBSERVATION

This table shows the total number of hours of observations recorded for the group of heifers at each age interval.

AGE OF HEIFERS	PERIOD OF OBSERVATION (hours)	AGE OF HEIFERS	PERIOD OF OBSERVATION (hours)
1 WEEK	19.75	11 MONTHS	22.75
2 WEEKS	29.50	12 MONTHS	28.75
3 WEEKS	24.25	13 MONTHS	26.25
4 WEEKS	17.00	14 MONTHS	17.95
5 WEEKS	15.25	15 MONTHS	18.75
6 WEEKS	9.50	16 MONTHS	28.25
7 WEEKS	8.75	17 MONTHS	19.50
8 WEEKS	5.00	18 MONTHS	16.50
3 MONTHS	14.25	19 MONTHS	16.25
4 MONTHS	18.25	20 MONTHS	16.00
5 MONTHS	18.00	21 MONTHS	16.00
6 MONTHS	22.25	22 MONTHS	16.75
7 MONTHS	12.75	23 MONTHS	15.00
8 MONTHS	12.00	24 MONTHS	14.25
9 MONTHS	24.00	25 MONTHS	20.00
10 MONTHS	28.75		

Table H2 MEAN VALUES OF PROPORTION OF TIME SPENT BY THE STUDY GROUP IN VARIOUS ACTIVITIES THROUGHOUT THE STUDY PERIOD

AGE (weeks)	PROPORTION OF TIME SPENT IN AN ACTIVITY					
	Restful	Cudding	Observation	Investigation	Ingestion	Grazing
0.5	0.54	0.00	0.27	0.07	0.05	0.00
1.5	0.49	0.00	0.23	0.11	0.05	0.00
2.5	0.42	0.03	0.22	0.15	0.08	0.00
3.5	0.37	0.05	0.20	0.13	0.13	0.00
4.5	0.31	0.19	0.16	0.12	0.12	0.00
5.5	0.26	0.24	0.18	0.10	0.10	0.00
6.5	0.34	0.14	0.22	0.07	0.13	0.00
7.5	0.10	0.16	0.28	0.13	0.20	0.00
10.0	0.25	0.24	0.19	0.06	0.18	0.00
14.0	0.14	0.36	0.17	0.11	0.12	0.00
18.0	0.12	0.37	0.13	0.12	0.15	0.00
22.0	0.25	0.26	0.15	0.09	0.15	0.03
26.0	0.37	0.20	0.15	0.04	0.09	0.09
30.0	0.16	0.27	0.16	0.04	0.01	0.26
34.0	0.16	0.33	0.08	0.01	0.00	0.33
38.0	0.27	0.59	0.12	0.03	0.00	0.22
42.0	0.34	0.29	0.11	0.02	0.02	0.16
46.0	0.31	0.28	0.14	0.02	0.05	0.15
50.0	0.17	0.31	0.28	0.01	0.07	0.16
54.0	0.14	0.21	0.35	0.04	0.12	0.03
58.0	0.11	0.48	0.16	0.05	0.11	0.00
62.0	0.12	0.42	0.19	0.03	0.17	0.00
66.0	0.13	0.43	0.18	0.03	0.17	0.00
70.0	0.14	0.35	0.23	0.03	0.15	0.05
74.0	0.12	0.17	0.27	0.03	0.10	0.24
78.0	0.19	0.19	0.18	0.03	0.00	0.34
82.0	0.17	0.28	0.16	0.00	0.00	0.34
86.0	0.21	0.36	0.09	0.00	0.00	0.27
90.0	0.27	0.31	0.11	0.00	0.00	0.26
94.0	0.19	0.30	0.08	0.00	0.00	0.37
98.0	0.18	0.33	0.13	0.01	0.00	0.23

Table H3 MEAN VALUES OF FREQUENCY OF OCCURRENCE OF VARIOUS ACTIVITIES THROUGHOUT THE STUDY PERIOD

AGE (WEEKS)	FREQUENCY OF OCCURRENCE PER HOUR						
	LiN	LOB	Voc	SShk	Jump	SRub	LiSelf
0.5	9.26	20.30	26.18	4.10	2.33	0.76	7.14
1.5	13.12	10.17	8.68	4.85	3.05	0.95	6.41
2.5	10.02	6.18	0.87	3.88	3.22	2.52	6.77
3.5	7.88	6.88	0.29	3.41	2.59	2.47	5.47
4.5	10.36	8.33	0.59	1.97	2.29	4.39	6.57
5.5	9.58	8.94	0.63	1.47	0.63	4.11	4.00
6.5	5.25	5.72	0.91	0.91	0.91	1.94	3.54
7.5	4.00	13.20	1.00	1.20	1.00	2.20	6.60
10.0	3.79	5.82	0.14	0.49	0.14	0.42	3.79
14.0	2.57	4.76	0.33	0.38	0.33	0.66	6.08
18.0	3.17	3.83	0.06	0.56	0.06	0.94	7.89
22.0	1.48	0.85	0.04	0.13	0.04	0.81	5.12
26.0	1.89	0.47	0.00	0.00	0.08	0.47	3.06
30.0	0.58	0.58	0.00	0.00	0.00	0.17	3.00
34.0	0.13	0.08	0.13	0.04	0.00	0.38	1.92
38.0	0.14	0.07	0.00	0.03	0.03	0.56	1.85
42.0	0.26	0.00	0.00	0.00	0.04	1.10	1.89
46.0	0.52	0.00	0.00	0.03	0.00	0.77	1.56
50.0	0.57	0.04	0.38	0.00	0.00	0.46	2.09
54.0	0.56	0.00	0.11	0.06	0.00	0.72	2.79
58.0	0.32	0.00	0.05	0.00	0.00	1.12	2.93
62.0	0.39	0.00	0.00	0.00	0.00	0.81	3.15
66.0	0.36	0.00	0.00	0.00	0.00	0.92	3.13
70.0	0.73	0.00	0.06	0.00	0.00	0.85	2.60
74.0	0.61	0.00	0.00	0.00	0.00	0.55	2.90
78.0	0.19	0.00	0.00	0.00	0.00	0.94	2.50
82.0	0.06	0.00	0.00	0.06	0.00	0.13	2.07
86.0	0.12	0.00	0.00	0.00	0.00	0.36	1.79
90.0	0.47	0.00	0.00	0.00	0.00	0.33	1.33
94.0	0.07	0.00	0.00	0.00	0.00	0.00	0.75
98.0	0.05	0.00	0.00	0.00	0.00	0.00	0.75

Table H3 MEAN VALUES OF FREQUENCY OF OCCURRENCE OF VARIOUS ACTIVITIES THROUGHOUT THE STUDY PERIOD (CONT.)

AGE (weeks)	SLA	FREQUENCY OF OCCURRENCE PER HOUR Movement	Investigate	Nose/lick calf	Nose/lick by calf	Agonistic initiate	Agonistic recieve
0.5	25.62	7.49	14.03	0.00	0.00	0.00	0.00
1.5	21.86	6.27	20.50	0.24	0.00	0.00	0.00
2.5	17.15	5.69	24.58	0.78	0.08	0.00	0.00
3.5	15.18	5.71	21.70	0.76	0.00	0.00	0.00
4.5	14.95	4.79	19.24	0.98	0.00	0.00	0.00
5.5	11.89	4.00	17.48	1.79	0.21	0.06	0.05
6.5	9.26	3.31	12.33	1.49	0.46	0.29	0.17
7.5	24.60	15.60	17.20	6.40	3.60	0.72	0.68
10.0	10.81	7.16	10.03	3.09	0.63	0.28	0.35
14.0	10.36	10.25	12.27	4.22	2.08	0.71	0.38
18.0	11.72	11.94	14.34	4.33	1.72	0.94	0.61
22.0	9.08	10.65	11.19	1.57	1.44	1.03	0.49
26.0	5.65	7.76	6.04	0.86	0.16	1.33	0.94
30.0	6.33	12.17	3.92	0.58	0.33	0.83	0.17
34.0	5.79	13.50	1.55	0.13	0.38	1.21	0.33
38.0	6.16	10.89	2.57	0.35	0.24	0.63	0.35
42.0	5.01	7.21	2.20	0.40	0.26	0.35	0.17
46.0	4.87	4.77	1.88	0.35	0.38	0.38	0.28
50.0	5.75	5.49	0.80	0.57	0.23	0.19	0.19
54.0	9.25	7.13	2.56	0.78	0.11	0.28	0.44
58.0	7.09	6.03	2.56	0.91	0.37	0.21	0.16
62.0	7.33	5.17	1.84	0.57	0.14	0.60	0.28
66.0	7.08	5.69	1.74	0.51	0.15	0.56	0.20
70.0	9.58	8.06	2.30	0.61	0.12	1.15	0.73
74.0	9.48	10.40	2.64	0.37	0.18	0.31	0.61
78.0	4.82	7.69	1.69	0.06	0.06	0.38	0.12
82.0	4.69	6.94	0.44	0.06	0.13	0.12	0.00
86.0	3.34	6.21	0.36	0.18	0.12	0.18	0.12
90.0	1.80	5.60	0.34	0.20	0.33	0.07	0.20
94.0	1.96	4.35	0.28	0.35	0.21	0.28	0.14
98.0	2.85	2.85	0.45	0.20	0.05	0.10	0.20

Table H4a) MEAN VALUES OF CORRECTED SCORES USED FOR PROPORTION TIME SPENT
IN AN ACTIVITY.

	REARING CONDITION									
	CH		CGI		HG1		HI		HG2	
ACTIVITY	MEAN	+S.D.	MEAN	+S.D.	MEAN	+S.D.	MEAN	+S.D.	MEAN	+S.D.
RESTFUL	297.4	93.7	123.2	72.6	183.3	75.4	97.3	46.1	146.9	44.1
CUDDING	52.8	48.5	241.0	88.3	222.6	59.2	307.7	95.7	222.6	74.2
OBSERVATION	162.8	33.4	101.6	49.8	82.0	28.8	164.6	47.9	95.2	26.4
INVESTIGATION	75.2	28.8	74.4	40.6	25.3	27.1	27.8	22.1	38.4	6.2
EATING	55.7	29.2	115.9	59.1	193.5	74.4	117.0	42.0	236.9	48.7

Table H4
MEAN VALUES AND STANDARD DEVIATIONS FOR VARIOUS ACTIVITIES
WHILE WITHIN A PARTICULAR REARING CONDITION

Table H4B) CORRECTED MEAN VALUES FOR FREQUENCY OF OCCURENCE OF AN ACTIVITY

ACTIVITY	REARING CONDITION											
	CH		CGI		HG 1		HI		HG 2			
	MEAN	+S.D.	MEAN	+S.D.	MEAN	+S.D.	MEAN	+S.D.	MEAN	+S.D.		
Licking nose	10.8	5.32	3.2	1.87	0.23	0.24	2.8	10.71	0.15	0.19		
Looking observer	11.1	6.25	4.9	2.67	0.15	0.31	0.0	0.0	0.02	0.09		
Vocalises	7.1	7.14	0.0	0.0	0.03	0.15	0.03	0.15	0.0	0.0		
Looking around	18.4	7.83	11.5	5.69	7.0	2.39	9.5	2.33	3.5	1.62		
Movement	5.5	3.10	10.7	6.07	13.3	4.30	6.4	1.83	6.0	1.62		
Investigation	20.1	7.51	14.1	6.53	2.7	1.12	2.3	1.26	0.6	0.41		
Standing shaking	3.4	2.45	0.52	0.41	0.02	0.07	0.01	0.05	0.01	0.05		
Jump	2.3	2.33	0.27	0.51	0.02	0.06	0.0	0.0	0.0	0.0		
Standing rubbing	2.8	1.88	0.63	0.47	0.61	0.46	0.96	0.55	0.31	0.32		
Licking self	5.9	3.08	6.1	2.49	2.1	0.99	3.1	1.06	1.7	0.84		
N/li calf			4.5	3.08	0.37	0.46	0.80	0.69	0.62	0.39		
N/li by calf			1.6	0.95	0.52	1.10	0.20	0.25	0.14	0.27		
Agonistic initiate			0.69	0.71	0.76	0.73	0.38	0.44	0.18	0.20		
Agonistic recieve			0.46	0.57	0.28	0.33	0.28	0.30	0.13	0.14		

NOTE - The abbreviations :- CH, CGI, HG1, HI and HG2 represent the rearing conditions - calf-house, calves grouped indoors, first grazing period, heifers housed indoors and second grazing period of the heifers respectively.

Table H4
MEAN VALUES AND STANDARD DEVIATIONS FOR VARIOUS ACTIVITIES WHILE WITHIN PARTICULAR REARING CONDITIONS

Figure H1a

DEVELOPMENT OF TIME SPENT IN PASSIVE ACTIVITIES WHILE WITHIN PARTICULAR REARING CONDITIONS.

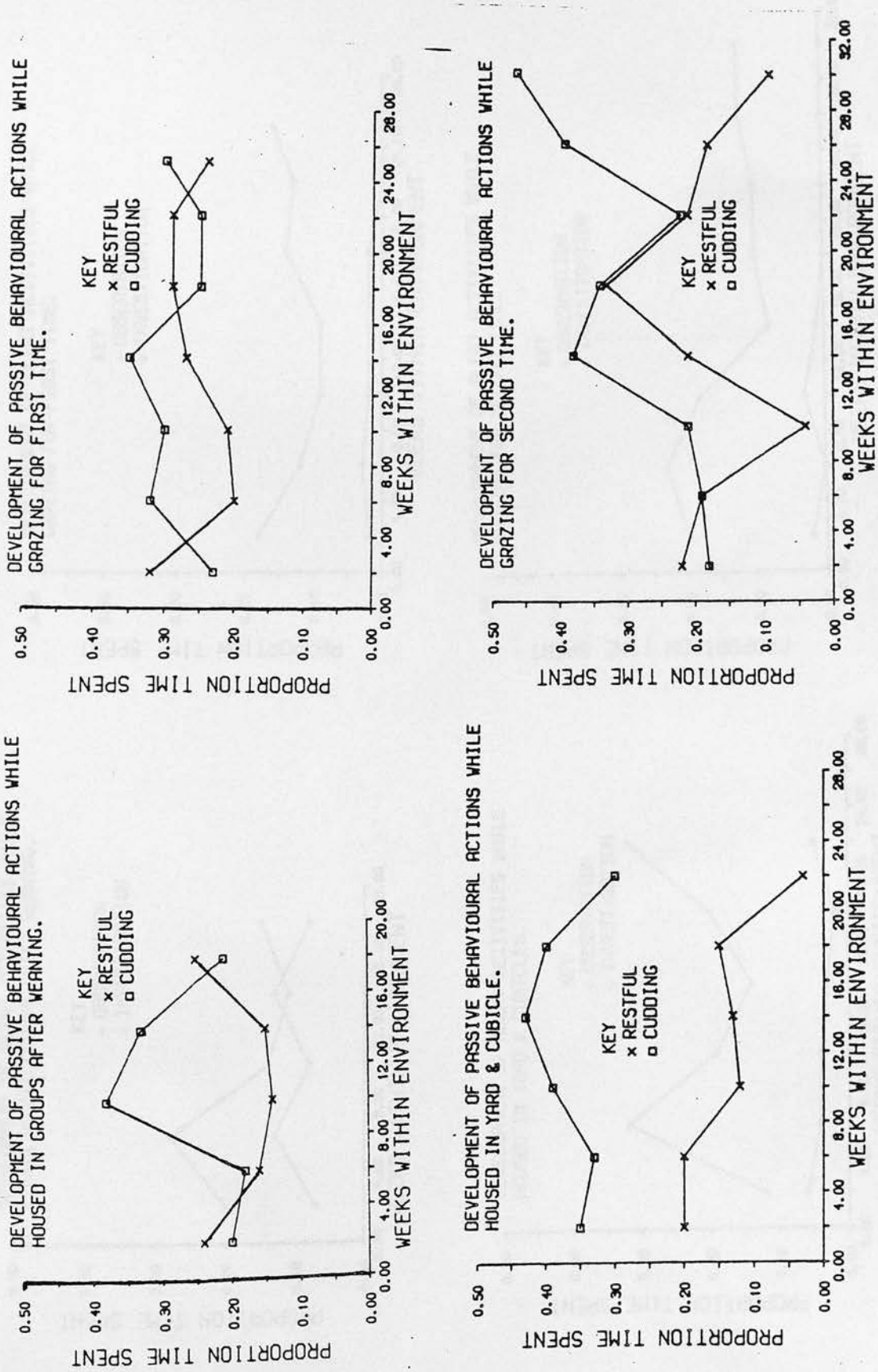


Figure H1b

DEVELOPMENT OF TIME SPENT IN ACTIVE BEHAVIOUR PATTERNS WHILE WITHIN PARTICULAR REARING CONDITIONS.

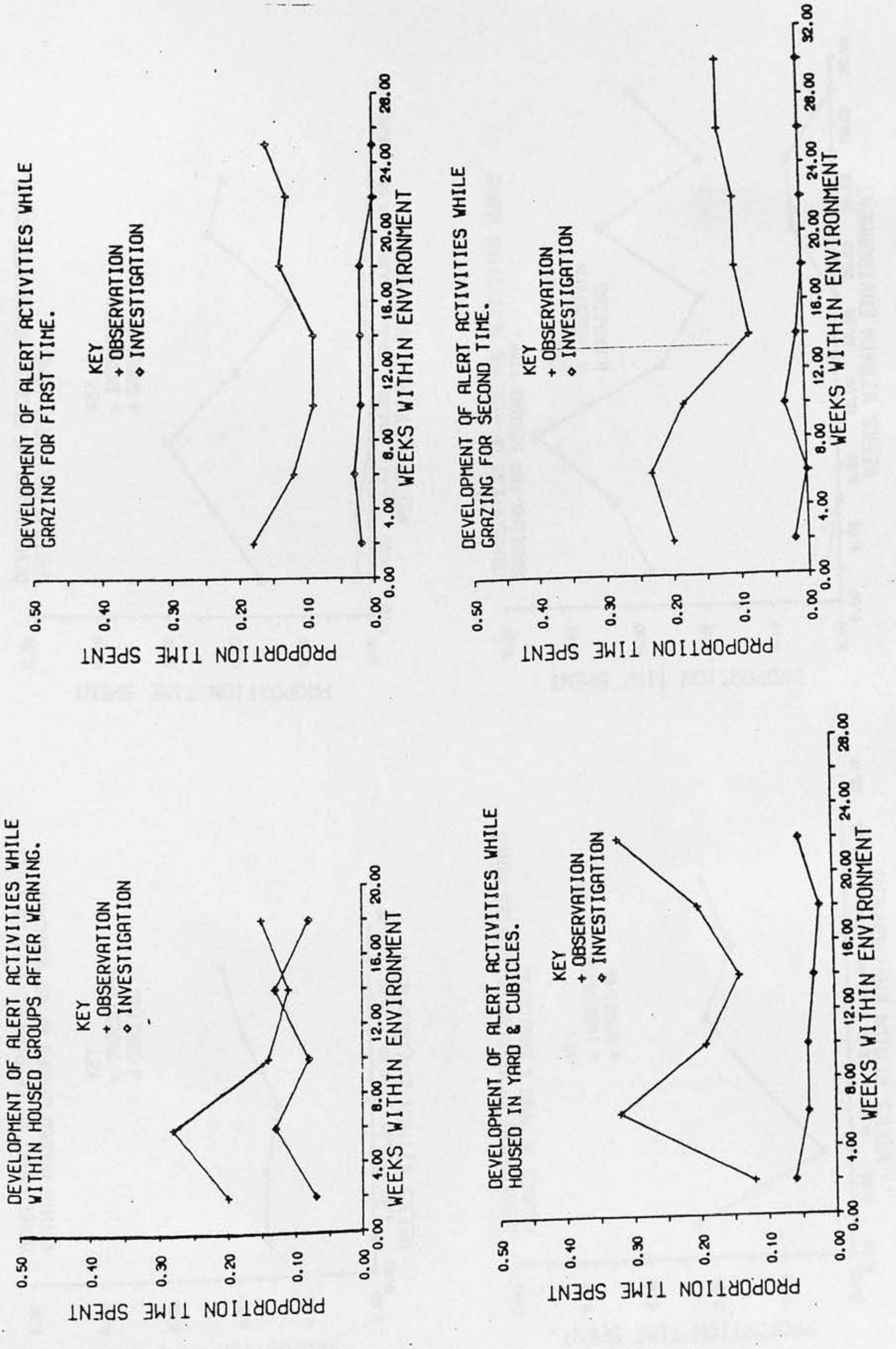
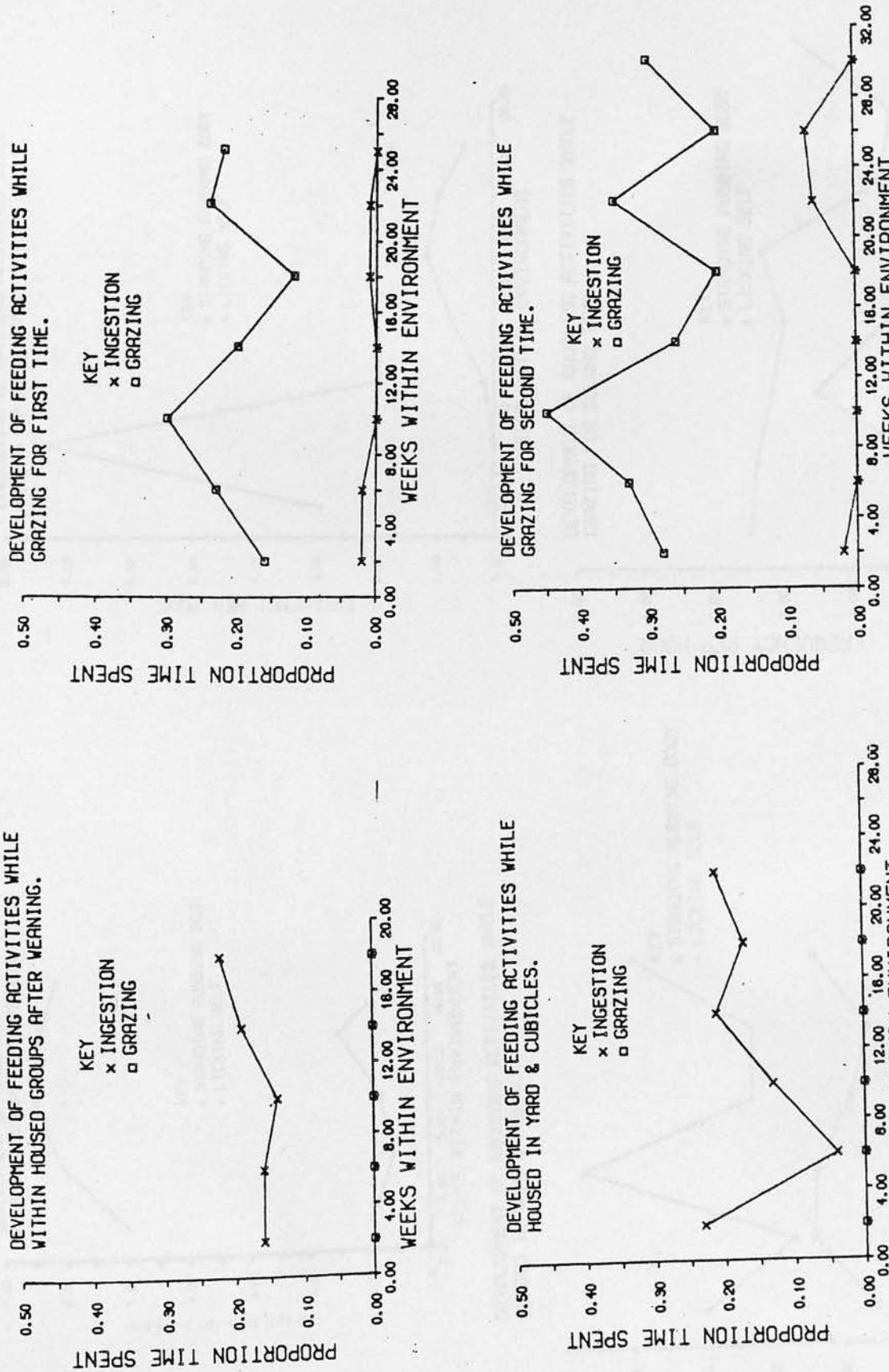
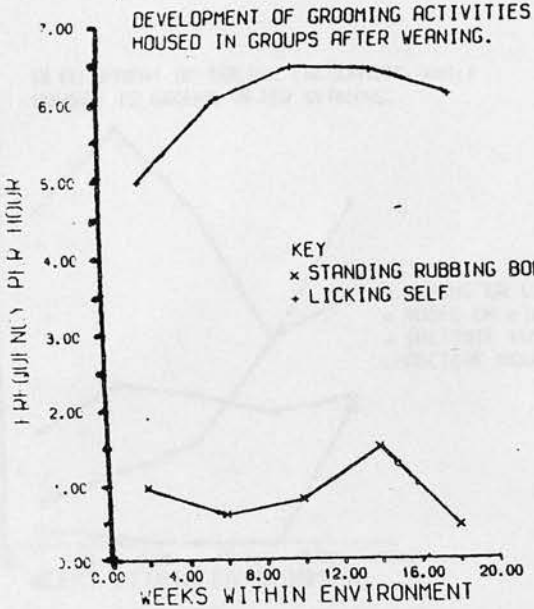
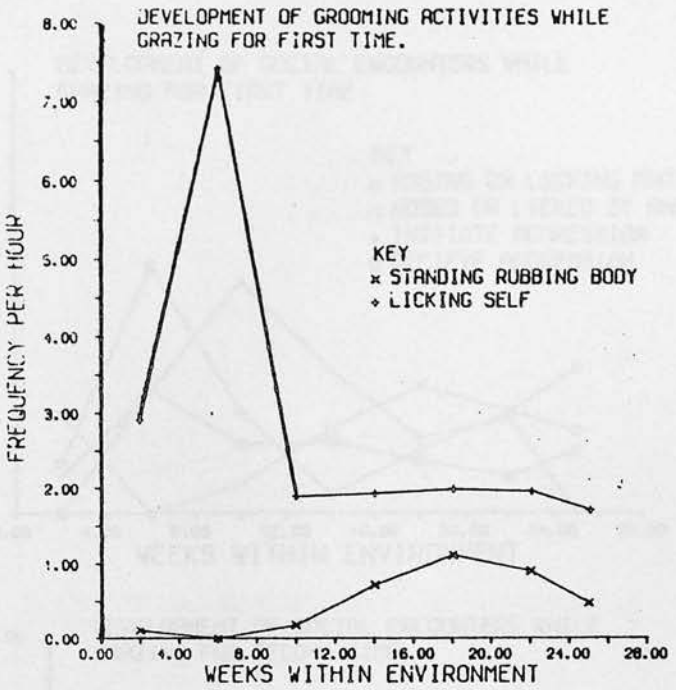


Figure H1c

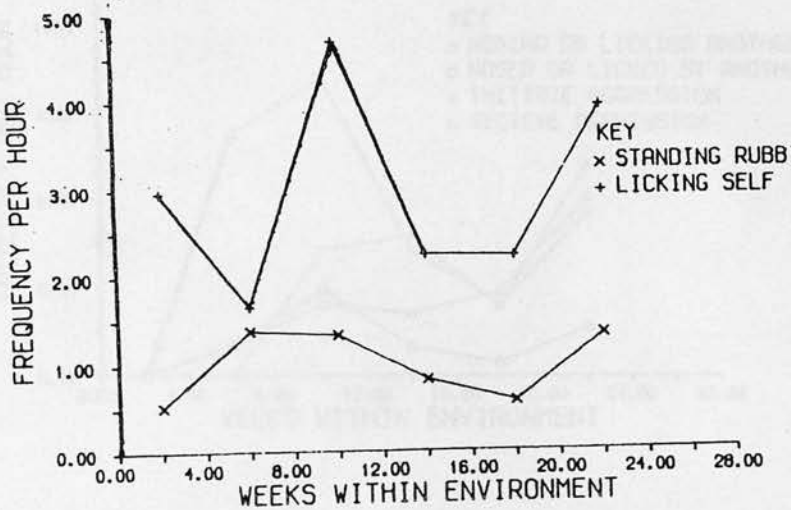
DEVELOPMENT OF TIME SPENT IN FEEDING ACTIVITIES WHILE WITHIN PARTICULAR REARING CONDITIONS.







DEVELOPMENT OF GROOMING ACTIVITIES WHILE
HOUSED IN YARD & CUBICLE.



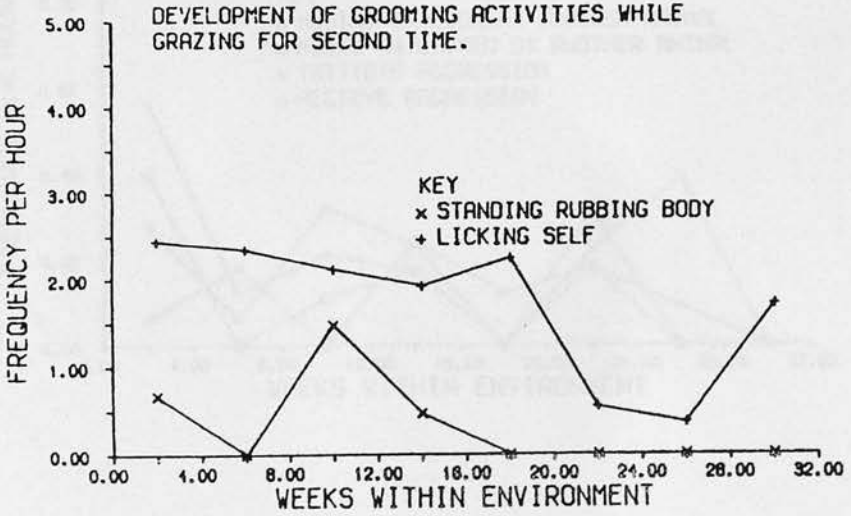
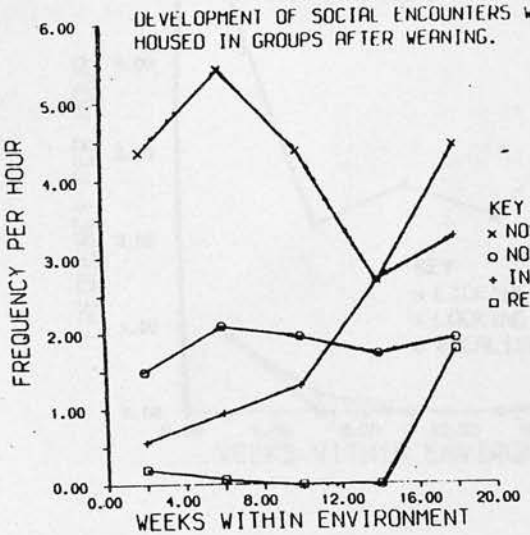
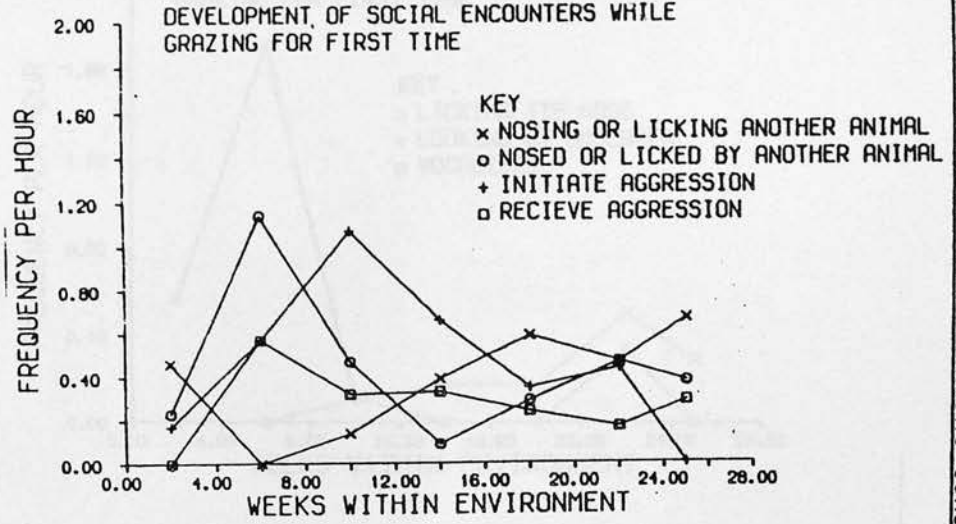
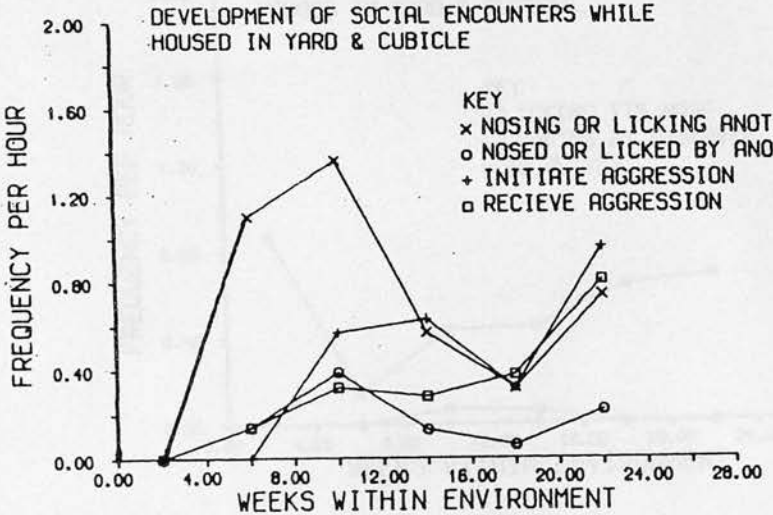


Figure H2a
DEVELOPMENT OF FREQUENCY OF OCCURRENCE OF GROOMING ACTIVITIES WHILE WITHIN PARTICULAR REARING CONDITIONS.







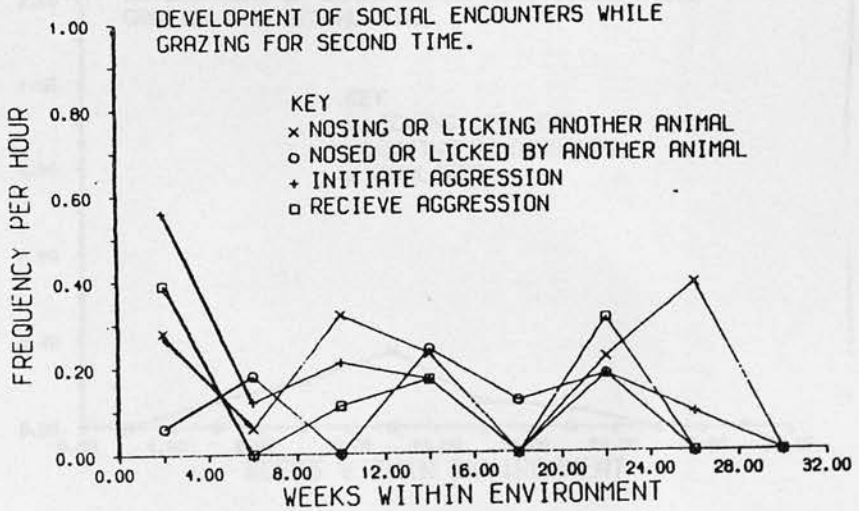


Figure H2b
DEVELOPMENT OF FREQUENCY OF OCCURRENCE OF SOCIAL ENCOUNTERS WHILE WITHIN PARTICULAR REARING CONDITIONS.

Figure H2c
DEVELOPMENT OF FREQUENCY OF OCCURRENCE OF SOME BEHAVIOURAL ACTIVITIES WHILE WITHIN PARTICULAR REARING CONDITIONS.

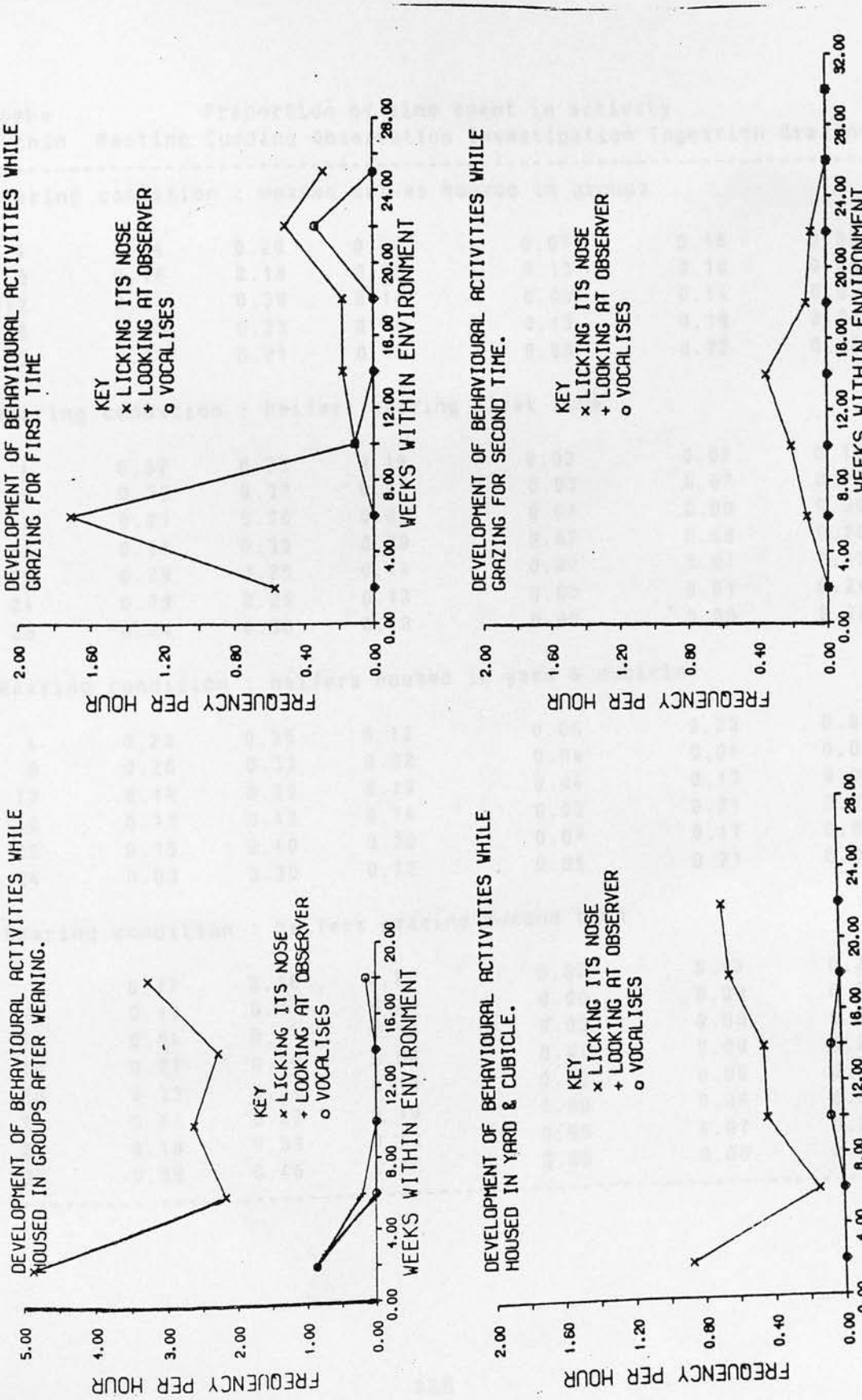


Table H5 PROPORTION OF TIME SPENT IN AN ACTIVITY WHILE WITHIN PARTICULAR REARING CONDITIONS.

Weeks Within	Proportion of time spent in activity: Resting	Cudding	Observation	Investigation	Ingestion	Grazing
Rearing condition : weaned calves housed in groups						
4	0.24	0.20	0.20	0.07	0.16	0.00
8	0.16	0.18	0.28	0.13	0.16	0.00
12	0.14	0.38	0.14	0.08	0.14	0.00
16	0.15	0.33	0.11	0.13	0.19	0.00
20	0.25	0.21	0.15	0.08	0.22	0.00
Rearing condition : heifers grazing first time						
4	0.32	0.23	0.18	0.02	0.02	0.16
8	0.20	0.32	0.12	0.03	0.02	0.23
12	0.21	0.30	0.09	0.02	0.00	0.30
16	0.27	0.35	0.09	0.02	0.00	0.20
20	0.29	0.25	0.14	0.02	0.01	0.12
24	0.29	0.25	0.13	0.00	0.01	0.24
26	0.24	0.30	0.16	0.00	0.00	0.22
Rearing condition : heifers housed in yard & cubicle						
4	0.20	0.35	0.12	0.06	0.23	0.00
8	0.20	0.33	0.32	0.04	0.04	0.00
12	0.12	0.39	0.19	0.04	0.13	0.00
16	0.13	0.43	0.14	0.03	0.21	0.00
20	0.15	0.40	0.20	0.02	0.17	0.00
24	0.03	0.30	0.32	0.05	0.21	0.00
Rearing condition : heifers grazing second time						
4	0.22	0.18	0.20	0.02	0.02	0.28
8	0.19	0.19	0.23	0.00	0.00	0.33
12	0.04	0.21	0.18	0.03	0.00	0.45
16	0.21	0.38	0.08	0.01	0.00	0.26
20	0.33	0.34	0.10	0.00	0.00	0.20
24	0.21	0.22	0.10	0.00	0.06	0.35
28	0.18	0.39	0.12	0.00	0.07	0.20
32	0.09	0.46	0.12	0.00	0.00	0.30

Table H6 FREQUENCY OF OCCURRENCE OF BEHAVIOURAL ACTIVITIES WHILE WITHIN PARTICULAR REARING CONDITIONS.

Weeks Within	Frequency of occurrence of activity						
	LiN	LOB	Voc	SShk	Jump	SRub	LiSelf
Rearing condition : weaned calves housed in groups							
4	4.87	0.87	0.87	0.77	0.82	0.97	4.97
8	2.17	0.20	0.00	0.27	0.54	0.61	6.03
12	2.62	0.00	0.00	0.40	0.10	0.81	6.44
16	2.27	0.00	0.00	0.36	0.06	1.49	6.39
20	3.26	0.00	0.15	0.15	0.15	0.44	6.07
Rearing condition : heifers grazing first time							
4	0.57	0.00	0.00	0.00	0.00	0.11	2.91
8	1.71	0.00	0.00	0.00	0.00	0.00	7.43
12	0.11	0.00	0.11	0.00	0.00	0.18	1.90
16	0.18	0.00	0.00	0.06	0.03	0.72	1.94
20	0.18	0.00	0.00	0.00	0.06	1.12	2.00
24	0.51	0.00	0.34	0.03	0.00	0.91	1.97
26	0.29	0.00	0.00	0.00	0.00	0.48	1.72
Rearing condition : heifers housed in yard & cubicle							
4	0.87	0.00	0.00	0.00	0.00	0.52	2.96
8	0.14	0.00	0.00	0.00	0.00	1.38	1.65
12	0.43	0.00	0.07	0.00	0.00	1.33	4.69
16	0.44	0.00	0.06	0.00	0.00	0.82	2.24
20	0.63	0.00	0.00	0.00	0.00	0.57	2.22
24	0.67	0.00	0.00	0.00	0.00	1.33	3.93
Rearing condition : heifers grazing second time							
4	0.00	0.00	0.00	0.00	0.00	0.67	2.44
8	0.12	0.00	0.00	0.00	0.00	0.00	2.34
12	0.21	0.00	0.00	0.00	0.00	1.47	2.11
16	0.35	0.00	0.00	0.04	0.00	0.47	1.92
20	0.12	0.00	0.00	0.00	0.00	0.00	2.24
24	0.09	0.00	0.00	0.00	0.00	0.00	0.54
28	0.00	0.00	0.00	0.00	0.00	0.00	0.36
32	0.00	0.00	0.00	0.00	0.00	0.00	1.71

Table H6 FREQUENCY OF OCCURRENCE OF BEHAVIOURAL ACTIVITIES WHILE WITHIN PARTICULAR REARING CONDITIONS. (cont.)

Weeks Within	SLA	Frequency of occurrence of activity Movement	Investigate	Nose/lick calf	Nosed/licked by calf	Agonistic initiate	Agonistic recieve
Rearing condition : weaned calves housed in groups							
4	14.51	9.95	15.54	4.36	1.49	0.56	0.20
8	12.41	11.52	15.25	5.42	2.10	0.95	0.07
12	10.87	9.81	12.68	4.38	1.96	1.31	0.00
16	10.92	15.34	18.57	2.69	1.73	2.69	0.00
20	10.37	12.44	15.56	4.44	1.93	3.26	1.78
Rearing condition : heifers grazing first time							
4	5.43	7.09	3.66	0.46	0.23	0.17	0.00
8	2.29	8.57	3.43	0.00	1.14	0.57	0.57
12	7.85	14.37	2.11	0.14	0.47	1.07	0.32
16	6.12	12.60	2.42	0.39	0.09	0.66	0.33
20	8.76	13.29	2.29	0.59	0.29	0.35	0.24
24	6.34	7.52	1.76	0.47	0.47	0.44	0.17
26	4.21	4.50	0.86	0.67	0.38	0.00	0.29
Rearing condition : heifers housed in yard & cubicle							
4	4.52	4.70	4.87	0.00	0.00	0.00	0.00
8	12.81	7.99	2.89	1.10	0.14	0.00	0.4
12	10.57	7.02	2.69	1.36	0.39	0.57	0.32
16	7.09	4.91	1.89	0.57	0.13	0.63	0.28
20	8.63	5.71	2.35	0.32	0.06	0.32	0.38
24	15.11	12.52	3.11	0.74	0.22	0.96	0.81
Rearing condition : heifers grazing second time							
4	5.72	8.89	2.72	0.28	0.06	0.56	0.39
8	5.35	6.03	0.55	0.06	0.18	0.12	0.00
12	8.00	9.58	1.79	0.32	0.00	0.21	0.11
16	3.76	8.08	0.59	0.23	0.24	0.17	0.17
20	0.35	2.94	0.00	0.00	0.12	0.00	0.00
24	2.16	4.72	0.40	0.22	0.18	0.18	0.31
28	1.44	1.26	0.09	0.39	0.00	0.09	0.00
32	2.86	3.71	0.00	0.00	0.00	0.00	0.00

APPENDIX I

Information relevant to sequence analysis.

Figure I1 EXAMPLE OF FIRST ORDER TRANSITION MATRIX FOR ANALYSING SEQUENCES OF BEHAVIOUR

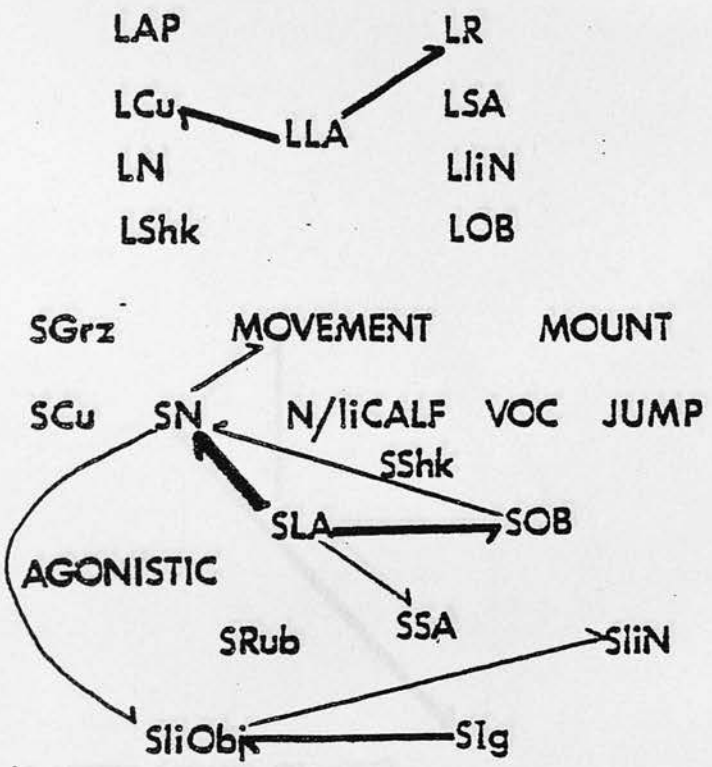
This figure shows a matrix which records the number of times a particular activity precedes another activity within a sequence of behavioural acts.

Behaviour code		Follow Activity 1	2	3	4	5	6	48	TOTAL
Precede Activity 1	I	0	18	21	0	0	0	1	44
2	I	49	0	29	0	3	1	1	101
3	I	5	77	0	8	0	2	5	143
4	I	0	1	13	0	1	4	1	22
5	I	1	0	0	0	0	1	0	2
6	I	0	2	2	1	0	0	2	17
.	.	.	.	.	.	.	. .....	.	.
.	.	.	.	.	.	.	. .....	.	.
.	.	.	.	.	.	.	. .....	.	.
48	I	0	0	21	3	0	0	0	138
TOTAL	I	50	110	139	18	5	16	136	2364

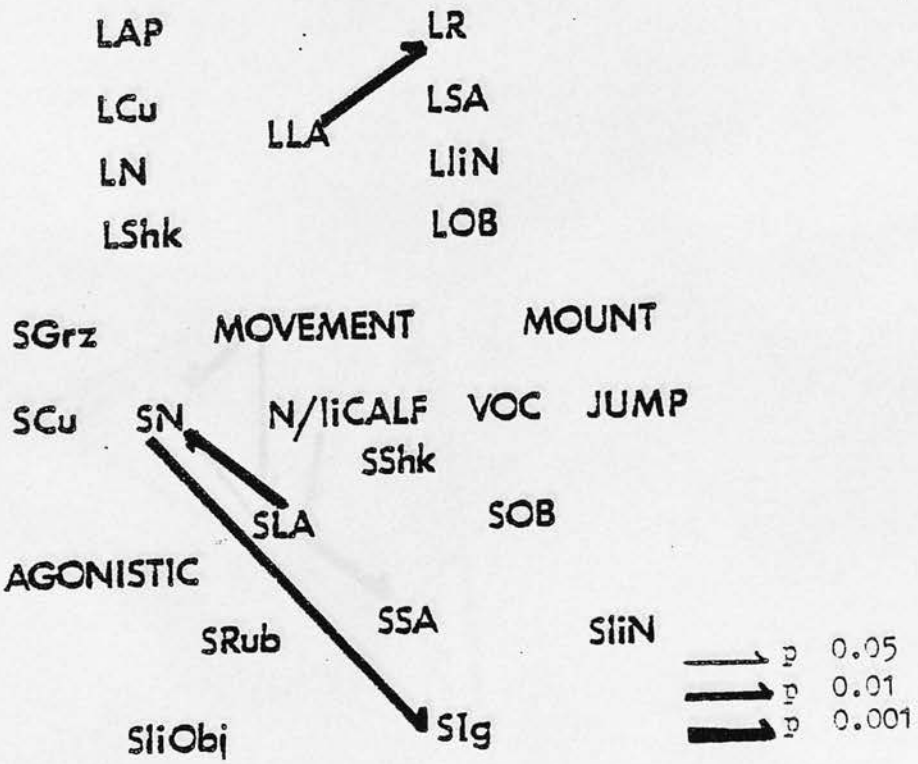
An Imp program written by Dr. J. Deag (in Dept. Zoology) uses these margin totals to evaluate the expected values for each cell of the table. The individual cells can then be tested using the Chi-square test statistic to determine whether any transitions are occurring more often than expected.

Figure I2

SIGNIFICANT TRANSITIONS BETWEEN BEHAVIOURAL ACTIVITIES AT VARIOUS AGES

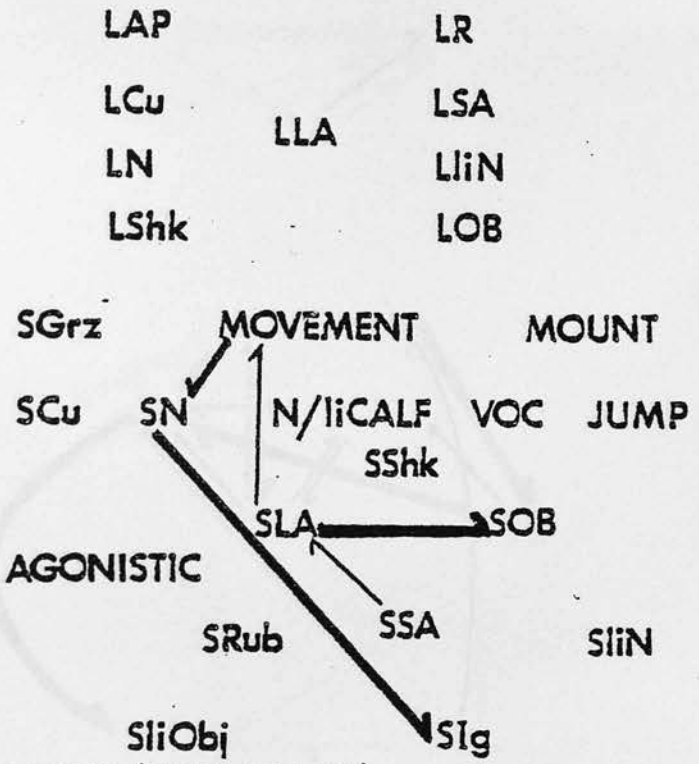


i) AGE = 6 WEEKS (CH)

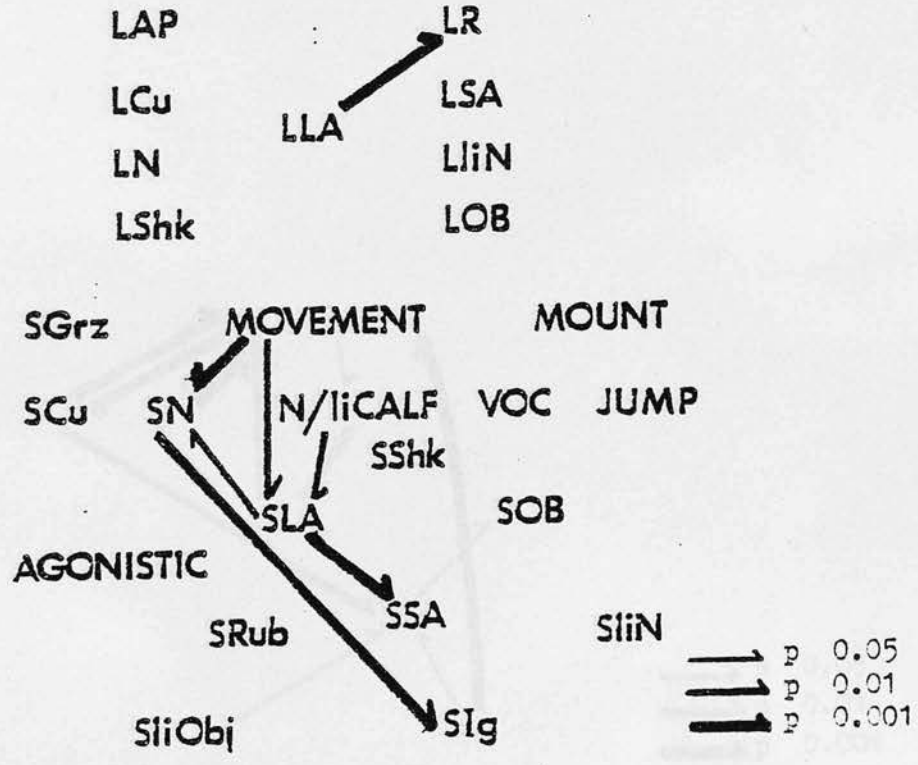


ii) AGE = 7 WEEKS (TRANS CH→CGI)

Figure I2 cont.

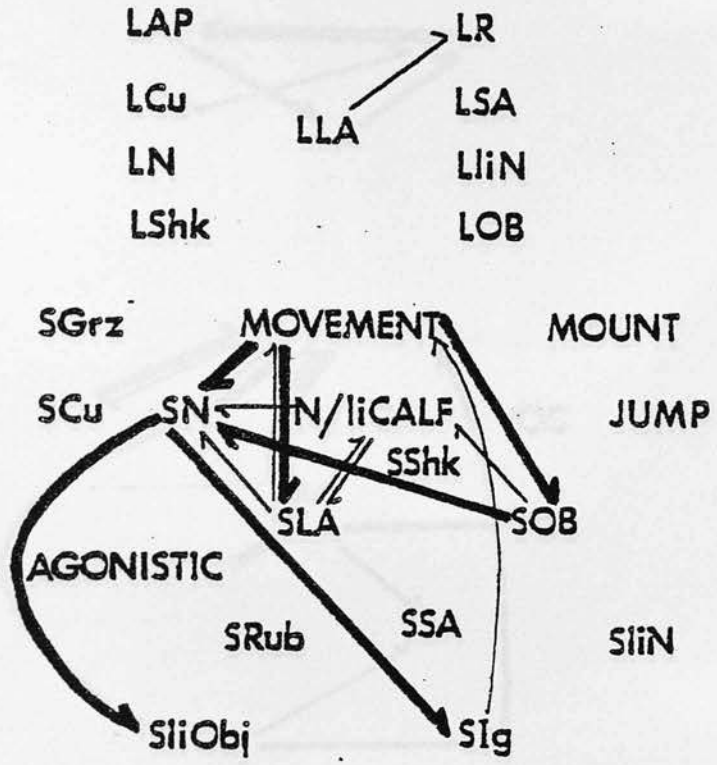


iii) AGE = 8 WEEKS (TRANS CH→CGI)

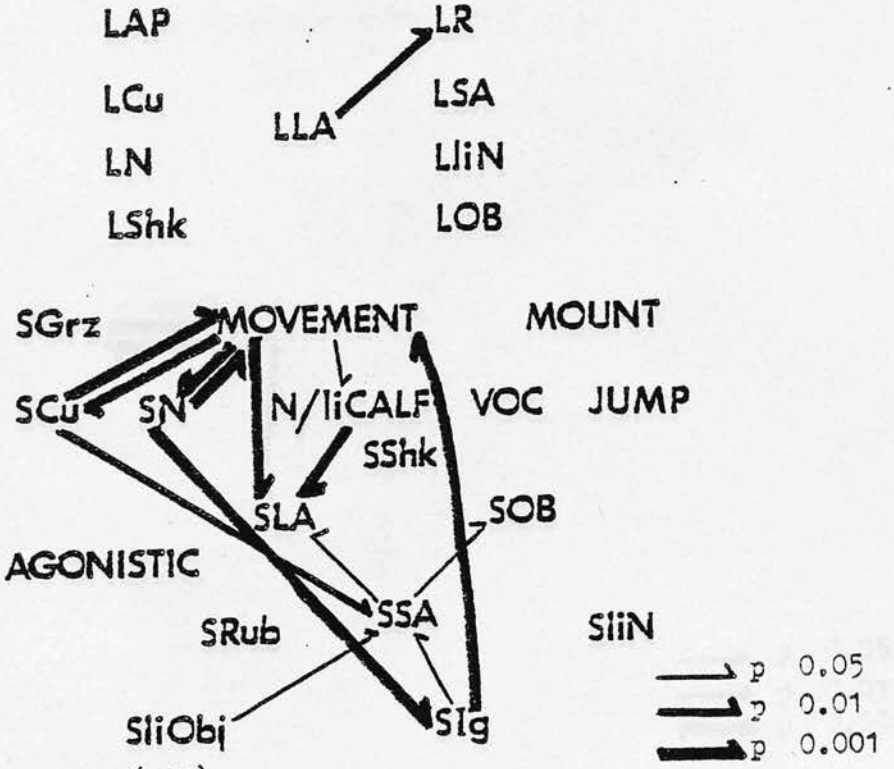


iv) AGE = 3 Months (CGI)

Figure I2 cont.

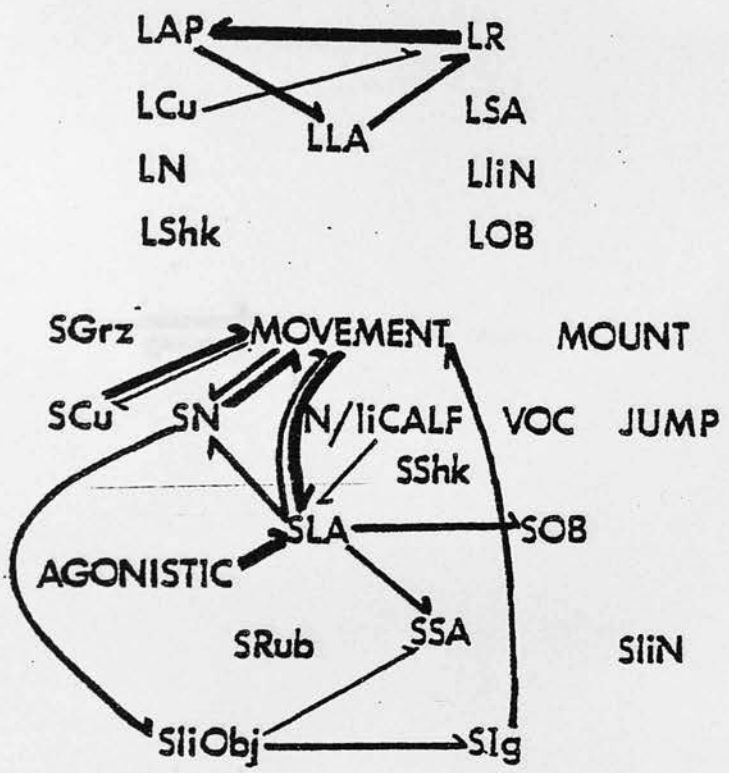


v) AGE = 4 MONTHS (CGI)

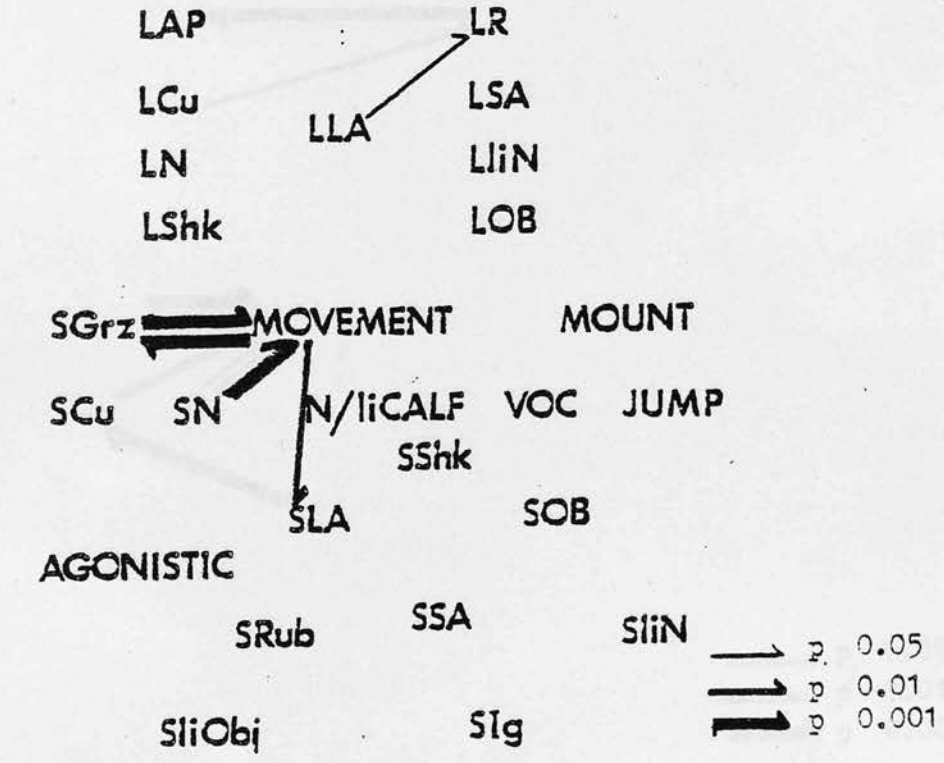


vi) AGE = 5 MONTHS (CGI)

Figure I2 cont.

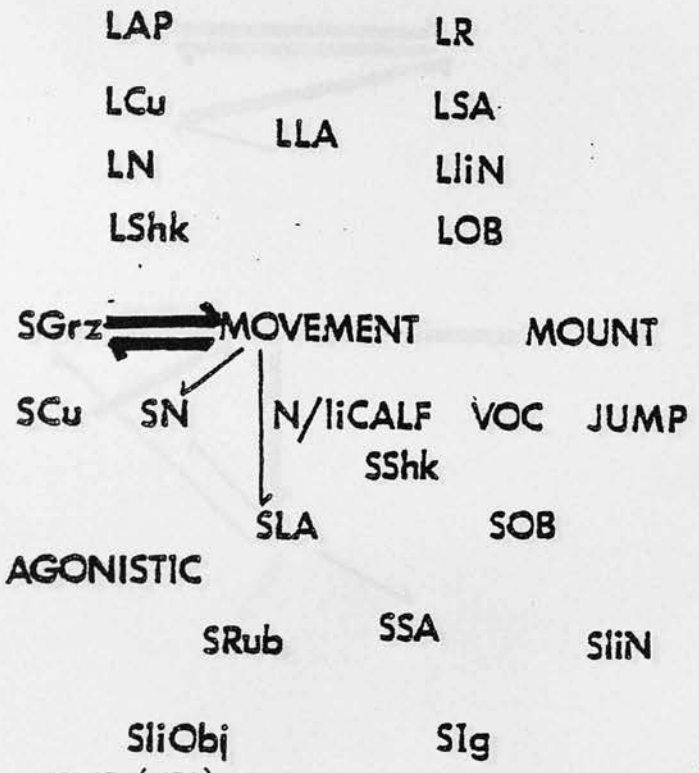


vii) AGE = 6 MONTHS (TRANS CGI→HG1)

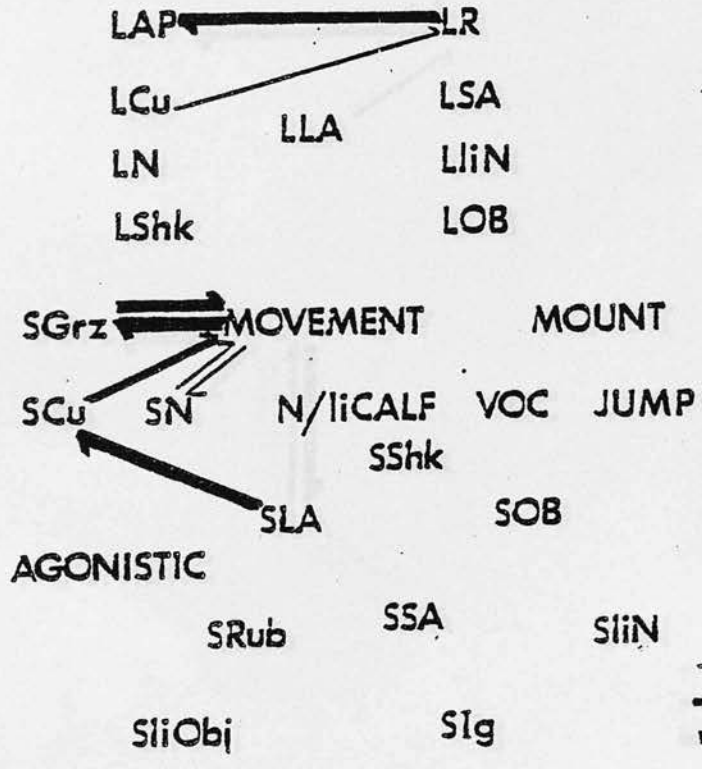


viii) AGE = 7 MONTHS (TRANS CGI→HG1)

Figure I2 cont.

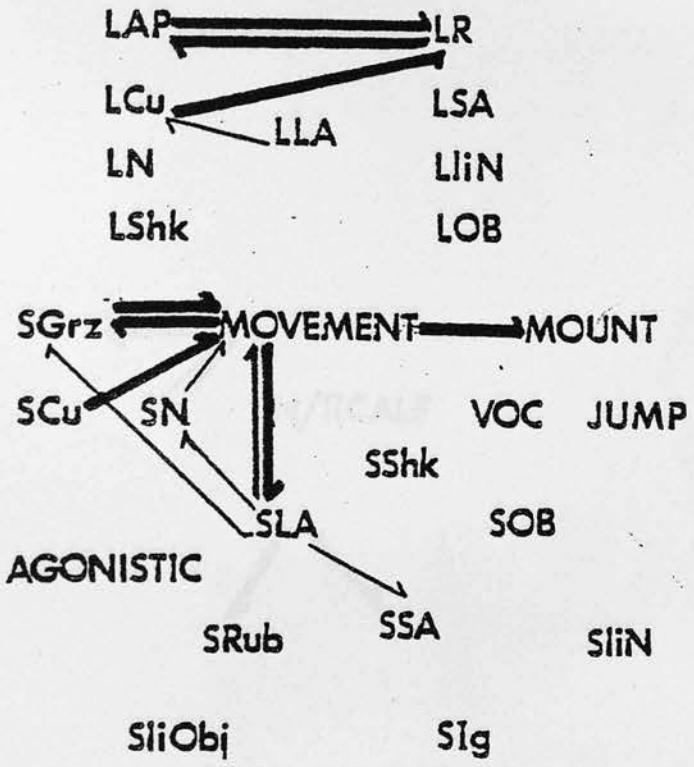


ix) ACE = 8 MONTHS (HG1)

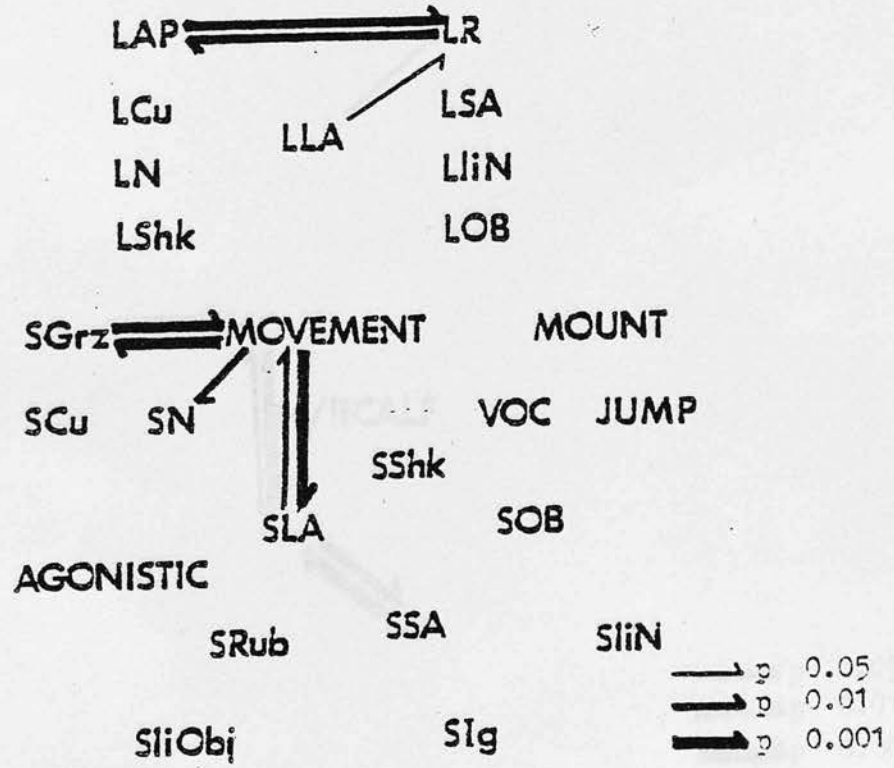


x) AGE = 9 MONTHS (HG1)

Figure I2 cont.

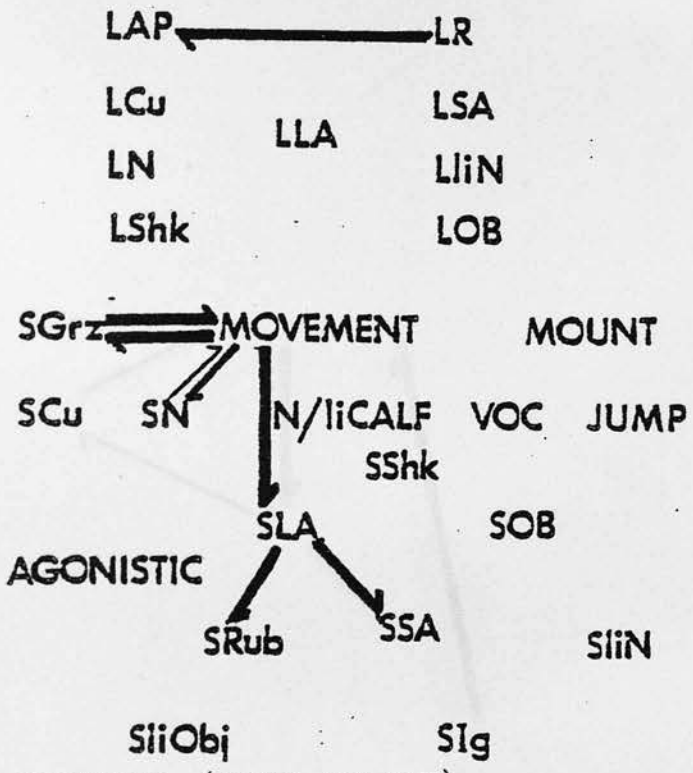


xi) AGE = 10 MONTHS (HG1)

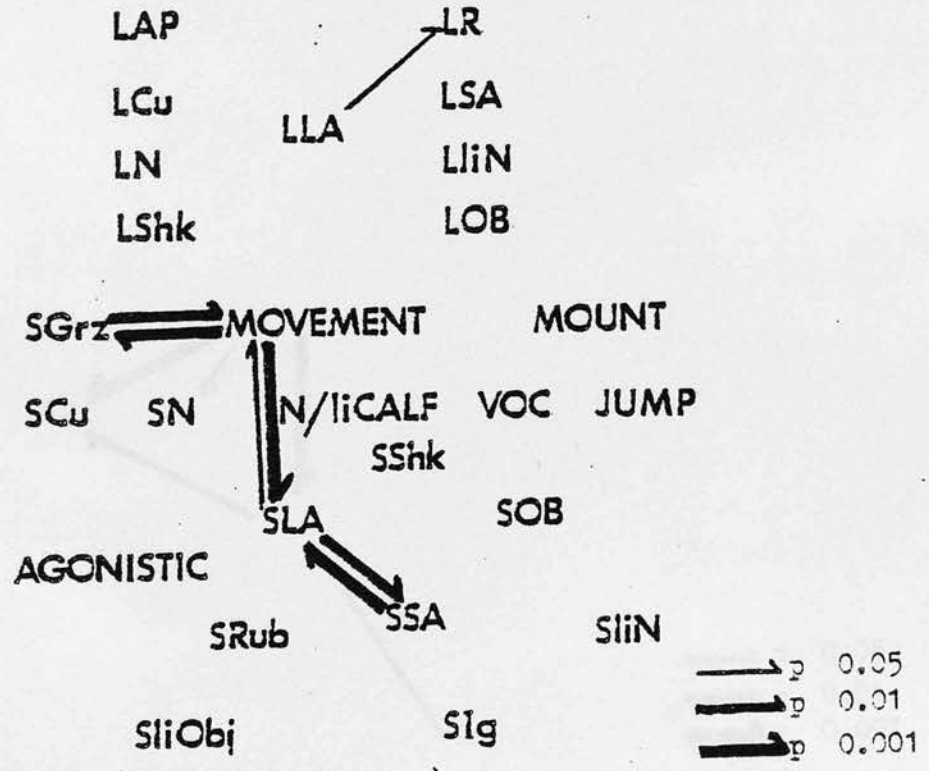


xii) AGE = 11 MONTHS (HG1)

Figure I2 cont.

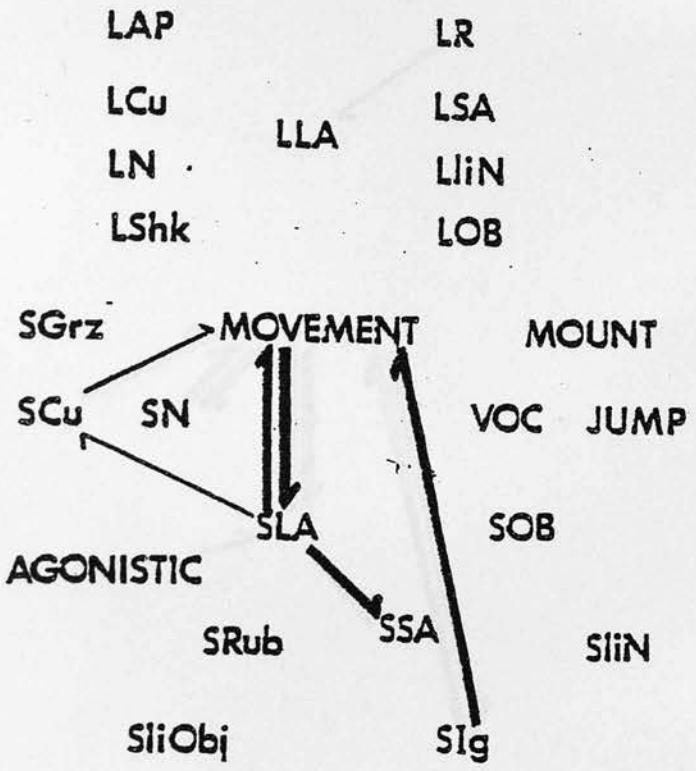


xiii) AGE = 12 MONTHS (TRANS HG1→HI)

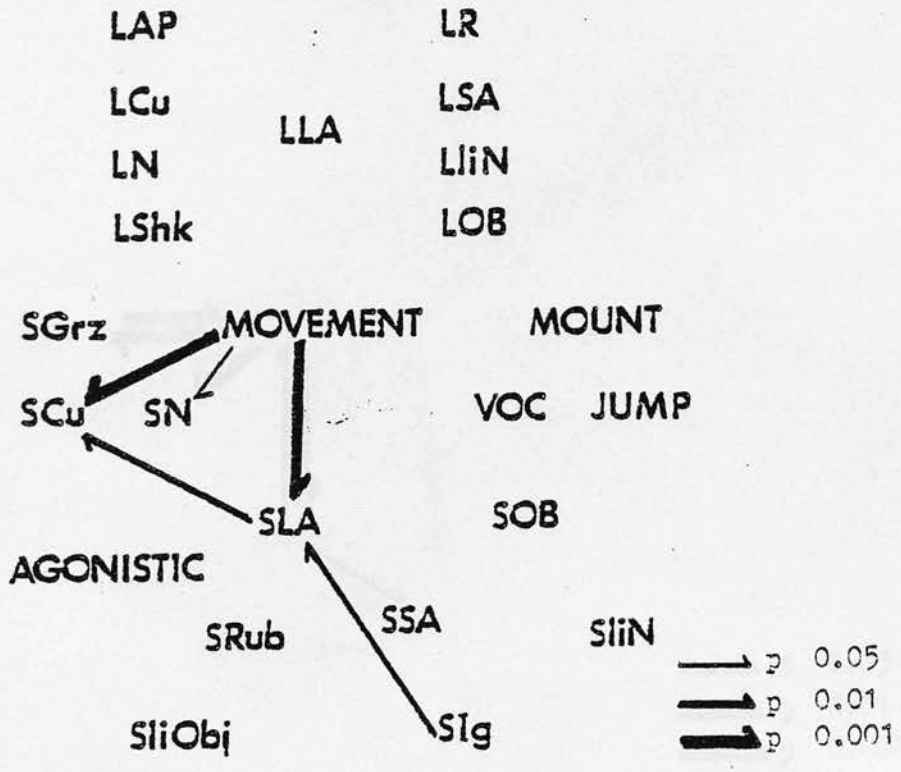


xiv) AGE = 13 MONTHS (TRANS HG1→HI)

Figure I2 cont.

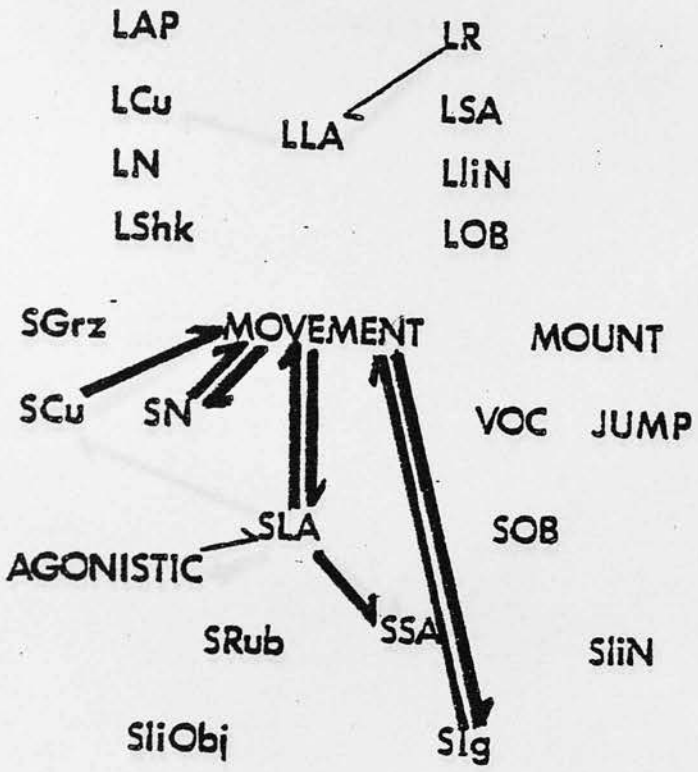


xv) AGE = 14 MONTHS (HI)

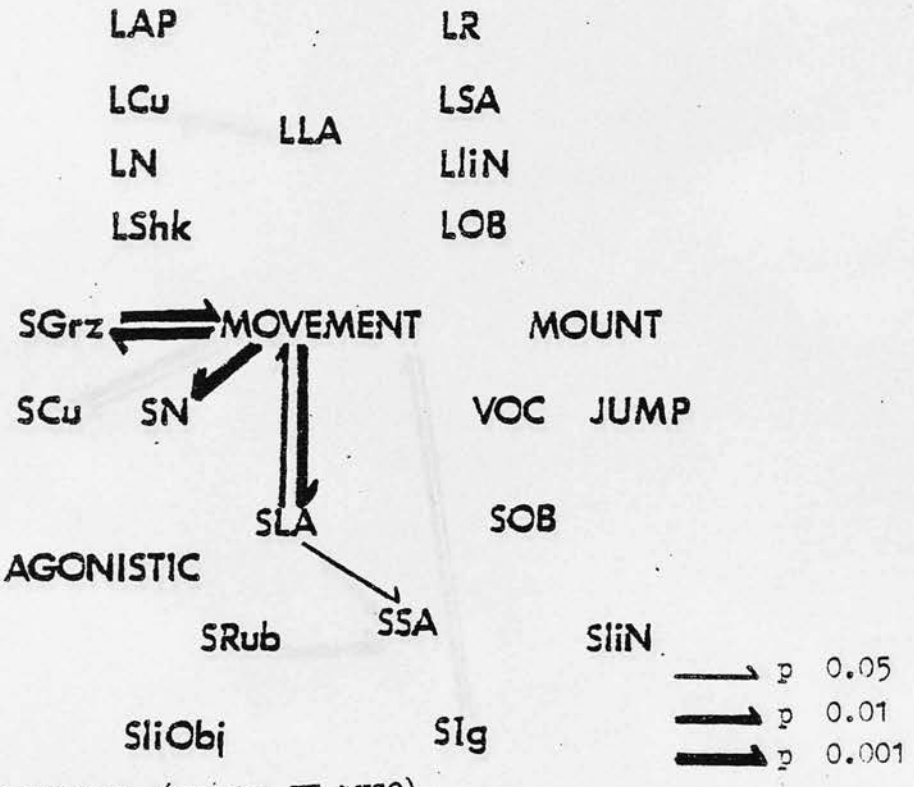


xvi) AGE = 15 MONTHS (HI)

Figure I2 cont.

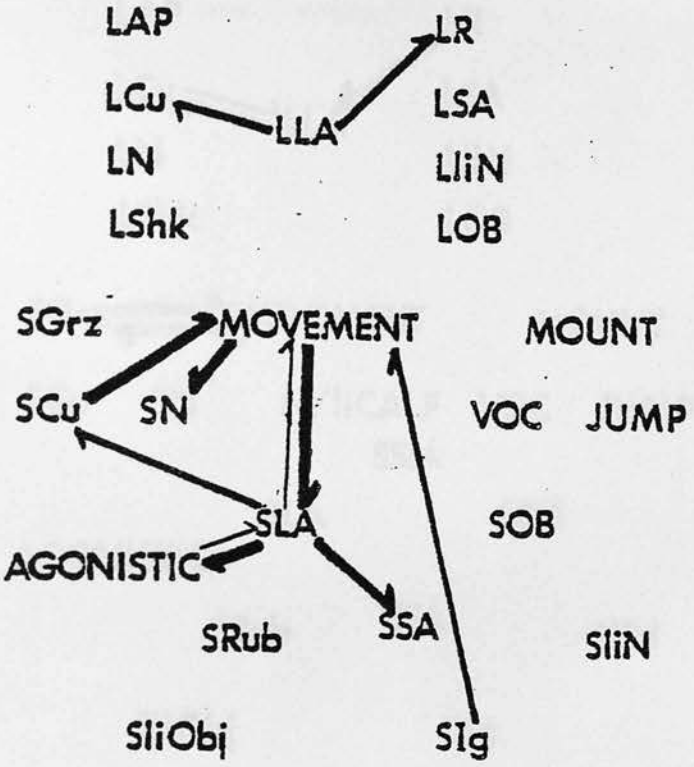


xix) AGE = 18 MONTHS (TRANS HI→HG2)

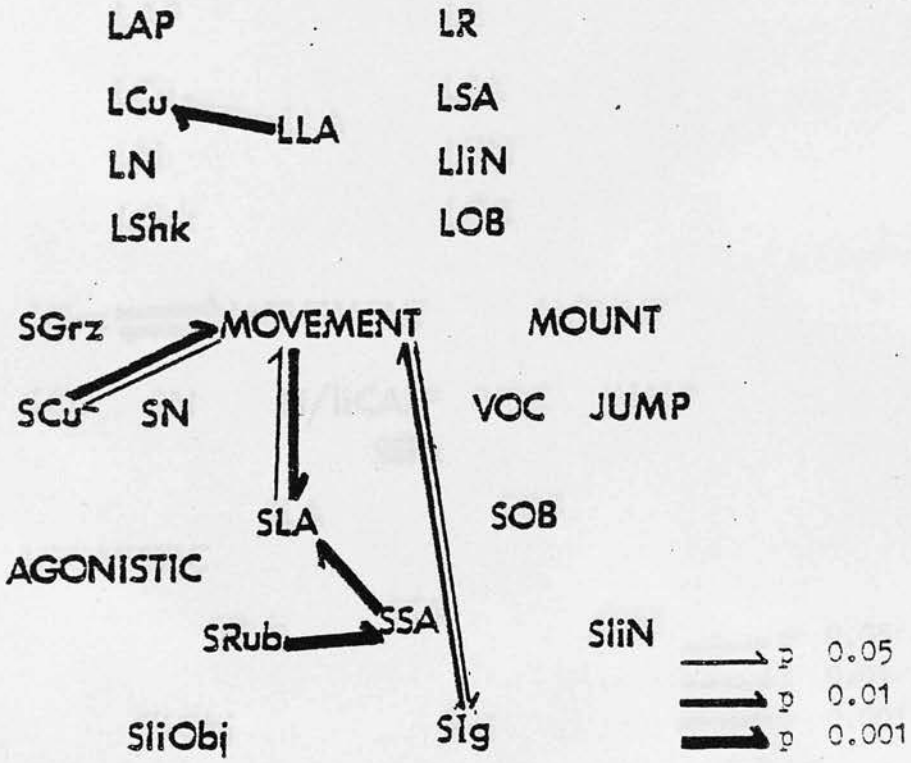


xx) AGE = 19 MONTHS (TRANS HI→HG2)

Figure I2 cont.

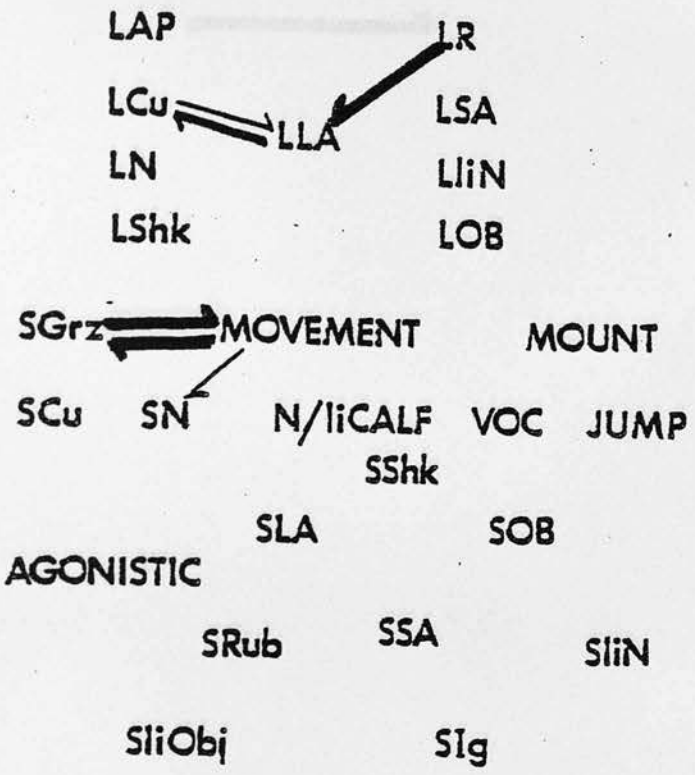


xvii) AGE = 16 MONTHS (HI)

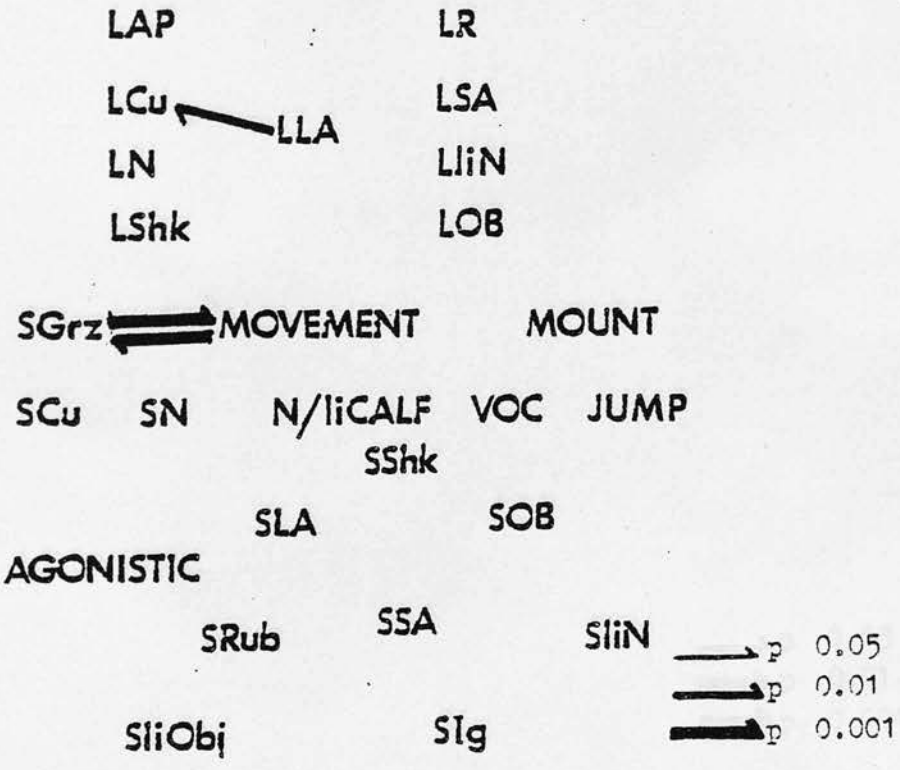


xviii) AGE = 17 MONTHS (HI)

Figure I2 cont.

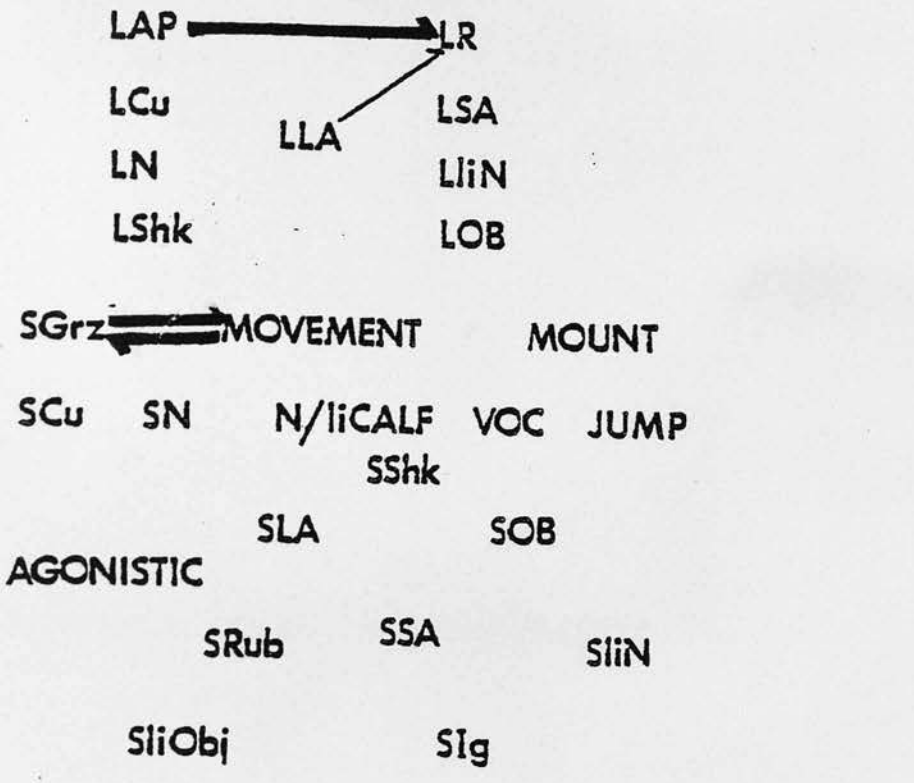


xxi) AGE = 20 MONTHS (HG2)

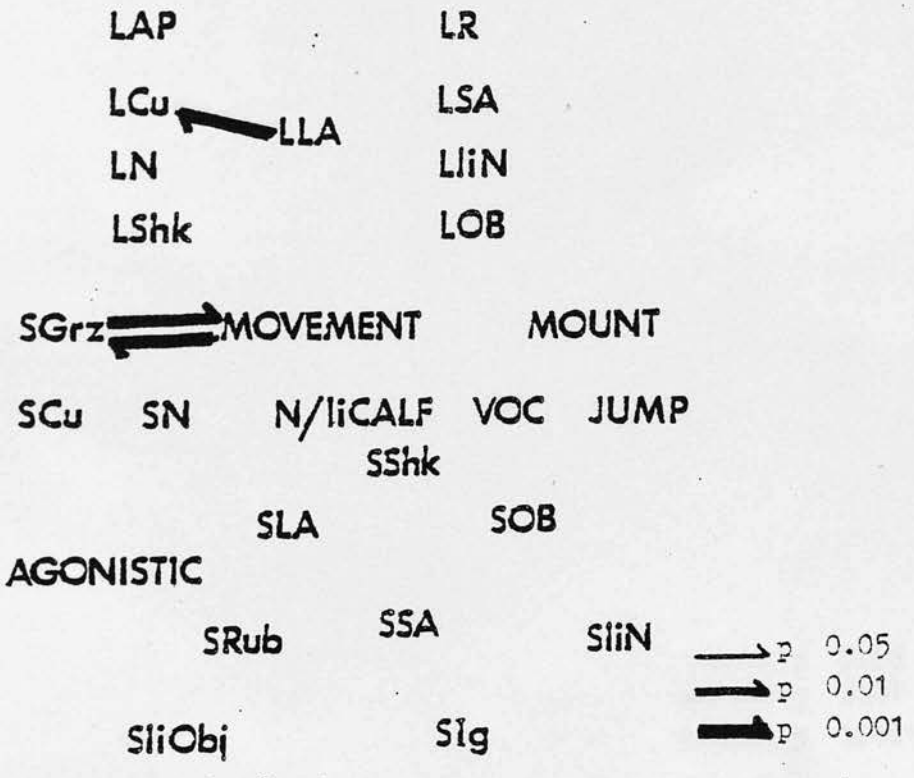


xxii) AGE = 21 MONTHS (HG2)

Figure I2 cont.

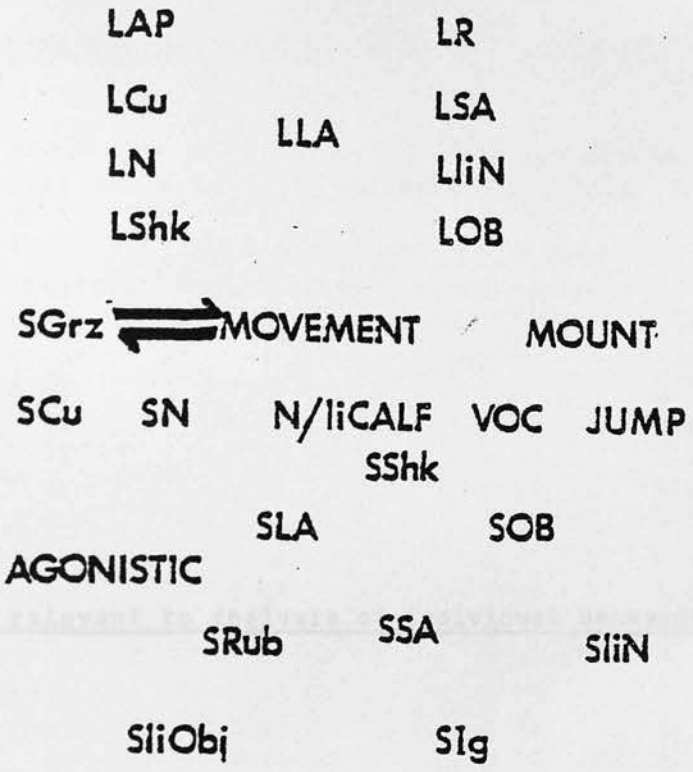


xxiii) AGE = 22 MONTHS (HG2)

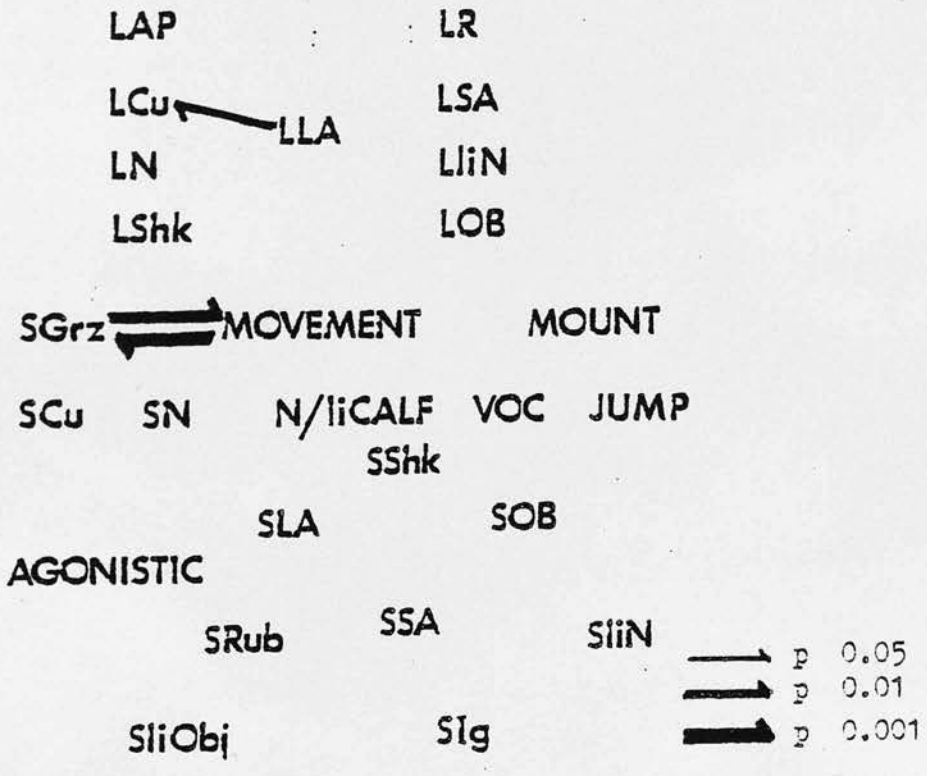


xxiv) AGE = 25 MONTHS (HG2)

Figure I2 cont.



xxv) AGE = 24 MONTHS (HG2)



xxvi) AGE = 25 MONTHS (HG2)

APPENDIX J

Data relevant to analysis of individual behaviour.

Table J1 SOCIAL PROFILE VALUES

This table shows the mean values for the expression of the three recorded social activities, as described in section 4.4.2.

	MEAN FREQUENCY OF OCCURENCE PER HOUR			
HEIFER	Noses/licks calf	Nosed/licked by calf	Agonistic initiate	Agonistic recieve
F130	0.96	0.49	1.24	0.22
F131	1.26	0.40	0.81	0.67
F132	1.27	0.35	0.26	0.53
F135	1.54	0.66	0.71	0.66
F136	0.54	0.23	0.59	0.36
F138	1.50	0.68	0.32	0.36
F143	1.80	0.56	0.47	0.17
F157	1.23	0.45	0.95	0.00
F163	1.00	0.27	0.14	0.37
F165	0.84	0.19	0.79	0.42
F166	0.19	0.24	0.38	0.24
F167	1.18	0.74	0.66	0.44
F168	0.32	0.09	0.82	0.45
F169	0.75	0.62	1.25	0.12
F170	0.71	0.13	0.36	0.13
F175	0.41	0.32	0.59	0.27
F178	0.64	0.14	0.09	0.09
F180	0.36	0.32	0.27	0.36
G1	0.36	0.64	0.14	0.14
G2	1.60	0.31	0.35	0.44

Table J2 SUMMARY OF CONSISTENT ASSOCIATIONS BETWEEN HEIFERS

This table shows the individuals which were recorded (and the periods in which they were recorded) more than once as the nearest neighbour to the focal animal.

FOCAL ANIMAL	NEAREST NEIGHBOUR DURING REARING PERIODS :-
F130	F131 - during Trans2, Trans4.
F131	F132 - during CGI, Trans2.
F132	no consistencies
F135	F136 - during HG1, Trans3, HI, Trans4, HG2.
F136	F135 - during CGI, Trans2, HG1, Trans3, HG2.
F138	F123 - during Trans3, HG2.
F143	no consistencies
F157	F166 - during CGI, HI.
	F163 - during Trans2, Trans4.
F163	F165 - during CGI, HI.
F165	F167 - during CGI, Trans4.
	F170 - during Trans4, HG2.
F166	F163 - during CGI, HG1, HI.
F167	F168 - during CGI, Trans3.
	F163 - during Trans2, HG2.
F168	F167 - during CGI, Trans3.
	F163 - during Trans4, HG2.
F169	F170 - during CGI, Trans2, HG1.
F170	F169 - during CGI, HG1.
F175	no consistencies
F178	F180 - during CGI, Trans4.
	F168 - during HI, HG2.
F180	no consistencies
G1	no consistencies
G2	no consistencies

Note - CGI-weaned calves housed indoors,
HG1-first grazing period,
HI -heifers housed over winter,
HG2-second grazing period and,
Trans2,3,4-transition period from one rearing condition to the next.

APPENDIX K

Data relevant to assessment of reactivity to touch and milking temperament.

Table K1 MEAN REACTIVITY SCORE FOR INDIVIDUAL HEIFERS IN PARTICULAR REARING CONDITIONS

This table shows the mean score for each heifer for reaction to touch over a period of approximately eight weeks while within a particular rearing condition. This data is shown graphically in section 4.4.1.

REARING CONDITION (cont. over)

HEIFER	CALF-HOUSE			WEANED CALVES GROUPED INSIDE					
	No. of tests	mean score	S.D. ±	No. of tests	mean score	S.D. ±	No. of tests	mean score	S.D. ±
F130	4	0.50	1.00	7	0.86	1.68	6	0.67	1.75
F131	4	0.00	0.82	7	-1.14	0.38	6	-1.67	0.51
F132	4	0.75	0.87	7	2.00	0.00	6	2.00	0.00
F135	5	0.80	1.09	7	0.14	1.77	6	2.00	0.00
F136	5	1.20	0.84	7	0.43	1.72	6	2.00	0.00
F138	3	-0.30	1.15	7	-1.57	0.53	6	-1.83	0.84
F143	3	0.30	2.08	8	1.25	1.03	8	1.62	0.52
F157	-	----	----	7	-0.75	1.49	7	1.71	0.49
F163	4	-1.00	1.41	7	-2.00	0.00	7	-2.00	0.00
F165	4	0.50	1.73	7	-1.43	1.13	7	1.28	1.15
F166	6	1.50	0.55	7	0.28	1.60	7	1.71	0.49
F167	6	1.50	0.55	7	1.43	1.51	7	1.71	0.49
F168	6	-1.00	1.55	7	-1.57	1.13	7	-1.71	0.49
F169	5	-0.20	1.64	7	-2.00	0.00	7	-2.00	0.00
F170	5	-0.80	1.09	7	-1.86	0.38	7	-2.00	0.00
F175	5	-0.40	1.34	7	-1.43	1.13	7	-1.29	1.11
F178	5	-0.20	1.09	8	-1.87	0.35	8	-2.00	0.00
F180	6	1.00	1.55	8	1.87	0.35	7	1.71	0.49
G1	4	0.25	1.50	8	-1.75	0.46	8	-2.00	0.00
G2	4	-1.25	0.50	8	-1.62	1.06	8	-2.00	0.00

Table K1 MEAN REACTIVITY SCORE FOR INDIVIDUAL HEIFERS IN PARTICULAR REARING CONDITIONS (cont.)

HEIFER	REARING CONDITION (cont. over) HEIFERS FIRST GRAZING PERIOD								
	No. of tests	mean score	S.D. ±	No. of tests	mean score	S.D. ±	No. of tests	mean score	S.D. ±
F130	6	1.33	1.63	6	2.00	0.00	7	2.00	0.00
F131	6	-2.00	0.00	6	-2.00	0.00	7	-2.00	0.00
F132	6	2.00	0.00	6	2.00	0.00	7	2.00	0.00
F135	6	1.83	0.41	6	2.00	0.00	7	2.00	0.00
F136	6	2.00	0.00	6	2.00	0.00	7	2.00	0.00
F138	6	-0.54	0.41	6	-1.50	0.55	6	-1.67	0.52
F143	5	2.00	0.00	6	2.00	0.00	5	2.00	0.00
F157	7	2.00	0.00	5	2.00	0.00	6	2.00	0.00
F163	6	-1.83	0.41	6	-2.00	0.00	6	-2.00	0.00
F165	6	2.00	0.00	6	2.00	0.00	6	2.00	0.00
F166	5	2.00	0.00	6	2.00	0.00	6	2.00	0.00
F167	5	2.00	0.00	6	2.00	0.00	6	2.00	0.00
F168	6	-1.83	0.41	6	-0.67	0.82	6	0.00	0.00
F169	6	-2.00	0.00	6	-2.00	0.00	DIED		
F170	5	-2.00	0.00	6	-2.00	0.00	6	-2.00	0.00
F175	6	0.00	1.55	6	2.00	0.00	6	2.00	0.00
F178	4	-2.00	0.00	6	-2.00	0.00	5	-2.00	0.00
F180	5	2.00	0.00	6	2.00	0.00	5	2.00	0.00
G1	6	-2.00	0.00	5	-2.00	0.00	5	-1.80	0.45
G2	6	-2.00	0.00	5	-2.00	0.00	5	-2.00	0.00

Table K1 MEAN REACTIVITY SCORE FOR INDIVIDUAL

HEIFERS IN PARTICULAR REARING CONDITIONS (cont.)

HEIFER	REARING CONDITION (cont.) HEIFERS HOUSED IN YARD OVER WINTER								
	No. of tests	mean score	S.D. ±	No. of tests	mean score	S.D. ±	No. of tests	mean score	S.D. ±
F130	4	2.00	0.00	7	2.00	0.00	5	2.00	0.00
F131	4	-1.00	0.00	7	-0.57	1.13	5	0.00	1.87
F132	4	2.00	0.00	7	2.00	0.00	5	2.00	0.00
F135	4	1.25	1.50	8	-0.38	1.51	4	-0.50	1.73
F136	4	2.00	0.00	8	2.00	0.00	4	1.25	1.50
F138	4	-1.75	0.50	5	-2.00	0.00	5	-1.40	0.55
F143	5	2.00	0.00	6	2.00	0.00	5	2.00	0.00
F157	3	2.00	0.00	8	2.00	0.00	4	2.00	0.00
F163	4	-2.00	0.00	8	-2.00	0.00	4	-2.00	0.00
F165	4	2.00	0.00	8	2.00	0.00	4	2.00	0.00
F166	4	2.00	0.00	5	2.00	0.00	5	2.00	0.00
F167	4	2.00	0.00	5	2.00	0.00	5	2.00	0.00
F168	4	-1.00	0.00	5	-1.00	0.00	5	1.40	1.34
F169	DIED								
F170	5	-1.80	0.45	5	-1.80	0.45	4	-2.00	0.00
F175	5	-0.60	1.52	6	-0.67	1.37	3	0.00	1.73
F178	5	-2.00	0.00	6	-2.00	0.00	4	-2.00	0.00
F180	5	2.00	0.00	6	2.00	0.00	4	2.00	0.00
G1	3	-1.67	0.58	8	-1.88	0.35	5	-2.00	0.00
G2	3	-2.00	0.00	8	-2.00	0.00	5	-2.00	0.00

Table K1 MEAN REACTIVITY SCORE FOR INDIVIDUAL HEIFERS IN PARTICULAR REARING CONDITIONS (cont.)

HEIFER	REARING CONDITION HEIFERS SECOND GRAZING PERIOD								
	No. of tests	mean score	S.D. ±	No. of tests	mean score	S.D. ±	No. of tests	mean score	S.D. ±
F130	6	-1.00	1.50	2	0.50	2.12	6	1.50	1.22
F131	6	-1.17	0.41	2	-1.00	0.00	6	-0.67	0.82
F132	6	2.00	0.00	2	2.00	0.00	6	2.00	0.00
F135	6	0.50	1.64	2	1.50	0.70	5	2.00	0.00
F136	6	1.50	1.22	2	2.00	0.00	5	2.00	0.00
F138	7	-1.86	0.38	5	-1.40	0.55	5	-1.80	0.45
F143	7	2.00	0.00	5	1.80	0.40	4	2.00	0.00
F157	8	1.25	1.39	5	0.20	1.09	4	-0.25	1.30
F163	8	-2.00	0.00	4	-2.00	0.00	4	-2.00	0.00
F165	7	2.00	0.00	4	2.00	0.00	4	2.00	0.00
F166	7	0.29	1.60	5	1.40	1.34	6	1.83	0.41
F167	7	2.00	0.00	5	2.00	0.00	6	0.83	1.47
F168	6	0.50	1.64	5	0.80	1.64	6	1.00	1.55
F169	DIED								
F170	8	-2.00	0.00	5	-2.00	0.00	5	-2.00	0.00
F175	9	1.33	1.32	5	0.20	1.64	4	1.25	1.50
F178	8	-2.00	0.00	5	-2.00	0.00	4	-1.75	0.50
F180	9	2.00	0.00	5	2.00	0.00	4	2.00	0.00
G1	6	-2.00	0.00	6	-2.00	0.00	3	-2.00	0.00
G2	6	-2.00	0.00	6	-2.00	0.00	3	-2.00	0.00

APPENDIX L

Production data.

Table L1 LIVEWEIGHTS OF THE HEIFERS OF THE STUDY GROUP AT VARIOUS AGES

HEIFER	BIRTH WT.	WEANING WT.	WEANING AGE	TURNOUT WT.	TURNOUT AGE	MID-SUMMER WT.	MID-SUMMER AGE	HOUSING WT.	HOUSING AGE	MID-WINTER WT.	MID-WINTER AGE	cont. over
F130	46.0	65.0	45	195	187	220	248	345	376	380	453	
F131	43.0	66.0	44	180	186	210	247	335	375	375	452	
F132	39.0	58.0	43	180	185	200	246	335	374	380	451	
F135	32.0	53.0	49	180	183	210	244	340	373	360	450	
F136	38.0	65.0	49	195	183	225	244	375	373	400	450	
F138	43.0	65.0	44	190	178	225	239	360	367	400	444	
F143	35.0	64.0	56	170	179	205	232	300	353	350	437	
F157	39.0	68.0	46	180	169	220	224	340	343	400	427	
F163	47.0	62.0	40	160	163	190	218	325	337	330	421	
F165	43.0	60.0	38	165	161	205	216	310	335	335	419	
F166	39.0	55.0	36	145	159	180	214	295	333	330	417	
F167	44.0	65.0	44	170	158	195	213	320	332	335	416	
F168	42.0	61.0	44	160	158	180	213	310	332	335	416	
F169	42.0	59.0	42	165	156	195	211	------DIED---------				
F170	42.0	59.0	42	160	156	190	211	305	330	330	414	
F175	47.0	72.0	48	155	150	195	205	315	324	375	408	
F178	34.0	55.0	47	140	159	175	203	290	322	325	406	
F180	37.0	44.0	44	150	156	165	200	280	319	315	403	
G1	41.0	54.0	37	120	149	165	193	290	312	290	396	
G2	35.0	46.0	36	120	148	130	192	235	311	250	395	

Table L1 LIVEWEIGHTS OF THE HEIFERS OF THE STUDY AT VARIOUS AGES (cont.)

HEIFER	TURNOUT		2nd MID-SUMMER		CALVING	
	WT.	AGE	WT.	AGE	WT.	AGE
F130	430	535	470	607	--------	
F131	445	534	500	606	--------	
F132	450	533	495	605	590	740
F135	445	532	465	604	610	869
F136	465	532	500	604	550	714
F138	460	526	500	598	550	727
F143	400	519	445	591	480	708
F157	480	509	485	581	545	734
F163	420	503	470	575	535	732
F165	400	501	455	573	525	835
F166	360	499	440	571	490	721
F167	415	498	445	570	515	735
F168	425	498	460	570	515	745
F169	----------		DIED		----------	
F170	430	496	465	568	510	722
F175	425	490	465	562	565	721
F178	420	488	430	560	--------	
F180	395	485	430	557	485	717
G1	400	478	440	550	--------	
G2	340	477	375	549	--------	

APPENDIX M - PUBLISHED PAPERS

Biology of Behaviour, 1984, *9*, 295-306

The early behaviour of suckler calves in the field

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Key words : Calves. Social behaviour. Creche behaviour. Behavioural sequences.

RESUME

Le comportement précoce du veau allaité au champ.

Pendant 9 semaines, depuis l'âge de 1 à 4 jours, 8 veaux issus de mères Hereford × Friesian et d'un taureau Aberdeen Angus ont été observés au pâturage, avec leur mère et d'autres vaches accompagnées de leurs veaux. Les données ont été recueillies du mois d'août jusqu'à la fin octobre et constituent 134 heures d'observation de 7 heures à 17 heures. Des observations à la fois de tout le groupe et d'un animal particulier ont été effectuées.

Les données sur le groupe ont permis d'établir les budgets temps alors qu'une analyse détaillée des séquences comportementales a été faite à partir des observations individuelles. En plus, l'analyse du groupement des veaux et du comportement de crêche a été faite à partir des localisations spatiales de veaux et d'autres données.

Le nombre de rapports entre une vache et son veau est passé d'une moyenne de 1,45 par demi-heure en première semaine à 0,15 en neuvième semaine. Au cours de la même période, la moyenne des rapports entre les veaux et les autres adultes est passée de 0,13 par demi-heure à 0,33 avec un pic en septième semaine. Le nombre moyen des rapports entre veaux était de 0,2 la première semaine et de 1,97 la septième semaine. Ces rapports comprenaient jeux sociaux et reniflements. Le temps passé debout était environ de 25 % de la première à la quatrième semaine, puis augmenta pour atteindre 45 % et plus durant les trois dernières semaines. Le pourcentage de temps en position couchée est tombé de plus de 72 % pendant les quatre premières semaines à 50,55 % de la septième à la neuvième semaine. La distance parcourue par les veaux était très variable, mais certains veaux parcouraient environ 300 m par demi-heure dans les trois dernières semaines. Le pourcentage de temps consacré au pâturage est passé de 0,67 % en troisième semaine à 16 % en huitième semaine. Quand ils se couchaient en crèches, presque la moitié des vingt veaux âgés de huit semaines s'allongeaient dans un rayon de 10 mètres autour du veau témoin.

L'analyse des séquences a montré que les points principaux du comportement à quatre semaines étaient la position de repos couché, debout à flairer et

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Tirés à part : D.G.M. WOOD-GUSH, à l'adresse ci-dessus.

debout à regarder. A huit semaines, les positions couché à regarder, couché à se reposer et debout à regarder constituaient les points principaux du comportement.

Mots clés : Veaux. Comportement social. Comportement de crèche. Séquences comportementales.

SUMMARY

Eight calves of Hereford × Friesian dams and an Aberdeen Angus bull were observed from days 1-4 of life for a period of nine weeks in fields with their dams and other cows with their calves. The observations were carried out from August until late in October and involved 134 hours of observation in the hours 0700-1700. Both scan and focal animal observations were made. The scans enabled time budgets to be constructed while the focal animal observations enabled detailed analysis of behaviour sequences to be made. In addition from spatial plotting of the calves and the other data, analysis was made of the calves aggregation and creche behaviour.

Interactions between a cow and her calf ranged from an average 1.45 per 30 minutes in the first week to 0.15 in the ninth week. Interactions between calves and other adults over the same period varied from an average of 0.13 per 30 minutes to 0.33 with a peak in the seventh week of 0.44. The mean number of interactions between calves were 0.22 in the first week, 1.97 in the seventh week and 1.73 in the last week. These interactions included social play and nose sniffing. The time spent standing was approximately 25 % from the first to the fourth week and increased to 45 % and over in the last three weeks. The percentage time lying dropped from over 72 % in the first four weeks to 50-55 % in the seventh to ninth weeks. The distanced moved by calves was very variable but some calves moved about 300 m per 30 minutes in the last three weeks. The percentage time spent grazing increased from 0.67 % in the third week to 16 % in the eighth week. When lying in creches, nearly half of the 20 calves at 8 weeks of age were lying within 10 meters of the focal (sample) calf.

The sequence analysis showed the focal points of behaviour to be lying resting, standing nosing and standing looking around at 4 weeks of age. At 8 weeks of age, lying looking around, lying resting and standing looking around were the focal points.

INTRODUCTION

The husbandry of veal calves is widely criticized in terms of their welfare and while many improvements can be made on an *ad hoc* basis, the solutions to the problems will ultimately lie in a fuller understanding of the behaviour of the calf. This objective can partially be fulfilled by studying its behaviour in a variety of conditions so that the development of its various motivational systems can be analysed and key environmental features assessed.

A small number of studies on calves outdoors have been carried out. Among these, the observations by Brownlee (1950, 1954) on the play behaviour of calves are now well-known. He described it in a comprehensive qualitative way, citing eleven different behaviour patterns any of which could occur together in a random sequence. He noted

that the play movements resemble those used in combat, self-defence, escape and reproduction. He reported that calves might be seen gambolling within an hour of birth and that butting might be seen in day-old calves. However he did not quantify his data but emphasised the motivation and function of play. Roy and his co-workers (1955) observed the behaviour of a group of five Dairy Shorthorn calves that were kept in a paddock without their dams. Over the first three to four weeks however, the calves were tethered so that they could not interact with one another. Detailed observations were made on the calves for 24 consecutive hours each month for 5 months. Scans at two minute intervals were made recording grazing time, ruminating time, standing time, lying time, hygiene time and frisking time. From these data time budgets were constructed. In a similar study in New Zealand, Nichol and Sharafeldin (1975) observed the grazing and nursing behaviour of 24 calves from birth to 120 days. They had been sired by either a Friesian or Angus bull from Angus or Angus cross cows. Unfortunately no details of the observation methods are given. Reinhardt *et al.* (1978, 1982) also reported on the interaction of calves but focussed their attention generally to calves of more than 2 to 3 months of age. In another report (1977) they mentioned that the cows in their study remained peripheral to the herd for a period of up to two weeks after the birth of the calf and only joined the herd in the third week when the calf joined the " kindergarten ". They mention that in these kindergartens the calves spend most of the day resting and playing. Other workers eg. Walker (1962) and Ewbank (1969) have recorded the frequency and duration of nursing in beef calves kept at grass with their dams.

From the academic point of view their early behaviour is of interest, firstly in relation to what Leuthold (1977) has described as the " fairly clear-cut dichotomy " of the hiding or following behaviour of the young in the species of Bovidæ. Secondly, in relation to their formation of creches and their bahaviour in the creches. Although mentioned by several authors (eg. Altmann, 1952 ; Estes, 1974 ; Lent, 1971 and Leuthold, *loc. cit.)*, the formation of creches, the behaviour of the calves within them and termination of creche behaviour have not been reported upon in detail for any of the Bovidæ.

The present study investigated the behaviour of beef calves at grass with their dams from 1-2 days of age until 8 weeks of age. The frequencies of all interactions with the dam, peers and other cows were recorded as well as the ages at which different types of behaviour appeared. The spatial distribution of the calves in creches was recorded. Their exploratory behaviour was noted and weekly changes in the frequency of different types of behaviour are given. Analyses of sequences of behaviour at two ages are shown. Finally, time budgets were constructed. The results are discussed in relation to the development of the calf and in relation to the creche behaviour of other Bovidæ and the welfare of the veal calf.

MATERIALS AND METHODS

Eight calves of Hereford × Friesian dams and an Aberdeen Angus bull were observed, one from the day of birth, two from day 1, three from day 2 and one each from days 3 and 4 of life. The calves could be individually identified by variations in coat colour and facial markings. They were born within 9 days of one another and formed part of a group of twenty, the rest of which were born over a longer period. The experiment ran from 23 August 1982 until 21 October 1982 and involved 134 hours of observation evenly distributed in the period 0700-1700 hours over the nine weeks. During the course of the nine week period all the animals were moved as a group to three different fields. However these were all fairly similar, being approximately 220 m square, bordered by hedges and hedgerow trees, but otherwise featureless and flat. Focal animal observations as described by Altmann (1974) were carried out on the 8 calves. Each focal animal observation period lasted 30 minutes and all the behaviour patterns shown in the ethogram on *table I* were recorded.

Table I : *The ethogram used in focal animal studies.*

Tableau I : *Ethogramme utilisé pour l'étude individuelle de l'animal.*

A) *Behaviour patterns performed by calf when lying*

1) Lie rest/sleep (LR)
2) Lie looking around (LLA)
3) Lie ingesting (LIg)
4) Lie ruminating (LCu)
5) Lie licking self (Lliself)
6) Lie nosing inanimate object (LN)

B) *Behaviour patterns performed by calf when standing*

7) Stand from lying, walk, lie down = movement
8) Standing looking around (SLA)
9) Stand idle (SId)
10) Stretch
11) Scratch
12) Run
13) Licking self (Sli self)
14) Grazing (SGr)
15) Ruminating (SCu)
16) Nose inanimate object (SN)
17) Rub body against inanimate object (SRub)
18) Lick inanimate object (Sli Obj)
19) Vocalize
20) Urinate
21) Defæcate
22) Yawn
23) Shake head
24) Avoid adult
25) Licking or nosing calf (SU/N Calf)
26) Licking or nosing dam (Sli/N Dam)
27) Push or butts other animal = Agonistic
28) Chase calf
29) Mount
30) Nose or butt udder
31) Nurse (S Suck)
32) Rub head against body of another calf or the dam
33) Mutual head rubbing by two calves or calf with the dam

C) *Behaviour patterns received by focal calf*

34) Nosed by calf while lying
35) Nosed by calf while standing
36) Nosed by dam while lying
37) Nosed by dam while standing
38) Nosed by other adult while lying
39) Nosed by other adult while standing
40) Licked by calf while lying
41) Licked by calf while standing
42) Licked by dam while lying
43) Licked by dam while standing
44) Licked by other adult while lying
45) Licked by other adult while standing

In addition scans were carried out every 10 minutes on the positions of all 20 calves and the behaviour of the focal calves was noted under the following categories: lying, standing, grazing, walking, nursing, interacting with another calf or the dam or another cow. Interactions with other calves were divided into (1) Social play which included a calf rubbing its head against the body of another calf, mutual head rubbing, rubbing noses and butting. Interactions with the dam, apart from nursing, included nosing her ie touching while sniffing; nosing the udder; "head rubbing" which consists of rubbing the heads in a playful manner or the calf rubbing its head against part of the dam's body; licking by the dam and licking the dam. Exploratory behaviour included sniffing objects while stationary or moving, examining objects visually or orally as well as standing looking around. Time budgets were prepared as percentages of time devoted to the activities recorded from these scans. There was no rain during the first three weeks of observation (weeks 0, 1 and 2) but it rained in the later weeks: In week 3 in 8 % of the focal animal observation periods, in week 4 in 17 %, in week 5 in 18 %, in week 6 in 24 %, in week 7 in 4 % and in week 8 in 6 % of the focal animal observation periods. The morning temperature at 0900 h varied from 16.9° C on September 17th to 5.6° C on October 16th.

The focal animal records were coded and the sequence of behaviour analysed in terms of transitions from one behaviour to the next. That is, a precede/follow matrix was obtained in which the values of the matrix indicate how often a particular behaviour was observed to be followed immediately by each of the other behaviours recorded. As lying behaviours are usually of longer duration and occur less frequently than those occurring while the animal is standing, the total number of transitions were divided into those occurring while the animal is lying and while the animal is standing. Diagrams of first-order transitions of the recorded behaviour of beef calves were then drawn by including only those behaviours which contributed more than 1 % of either total.

RESULTS

In *table II* are shown the mean frequencies of the different types of social interactions that were recorded. Interactions with the dam ranged from an average of 1.45 per 30 minutes in the first week to 0.15 per 30 minutes in the last week. The calves interactions with other cows tended to remain fairly constant over the period and included a proportion of threats from the adult. These increased from 0.03 per 30 minutes in the first week to an average of 0.13 per 30 minutes in the last three weeks. However no aggression between dam and calf

Table II : *The frequencies of certain behaviour patterns, the percentage time devoted to certain categories of behaviour together with the distance moved, per thirty minute period, in each of the nine weeks of observation.*

Tableau II : *Fréquence de certains types de comportement, pourcentage de temps consacré à certaines catégories de comportement en rapport avec la distance de mouvement, par périodes de trente minutes, pendant chacune des neuf semaines d'observation.*

Activity		Age in weeks 0	1	2	3	4	5	6	7	8
Calf-Dam * Interactions (non-suckling)	Av	1.45	0.5	0.54	0.35	0.76	0.29	0.68	0.1	0.15
	Range	0-8	0-10	0-4	0-7	0-8	0-5	0-5	0-4	0-2
Calf-other Adult * (Excluding interactions with the dam)	Av	0.13	0.11	0.15	0.34	0.18	0.14	0.44	0.12	0.33
	Range	0-2	0-2	0-2	0-3	0-1	0-3	0-3	0-1	0-2
Calf-peer * All interactions	Av	0.22	0.39	0.73	0.63	1.44	0.64	1.97	1.93	1.73
	Range	0-2	0-7	0-6	0-5	0-5	0-2	0-9	0-6	0-7
Calf-peer * Social play	Av	—	—	0.11	0.2	0.32	0.18	0.72	0.69	0.6
	Range	—	—	0-2	0-3	0-4	0-1	0-5	0-2	0-4
Calf-peer * Nosing sniffing	Av	0.24	0.39	0.62	0.43	1.09	0.45	1.16	1.12	1.07
	Range	0-2	0-4	0-5	0-3	0-3	0-2	0-4	0-4	0-3
Nosing Sniffing * Environment	Av	2.79	3.89	2.61	1.53	1.88	0.87	2.6	3.26	2.01
	Range	0-15	0-12	0-9	0-7	0-9	0-6	0-16	0-19	0-7
Scratching self *	Av	0.03	0.11	0.42	0.18	0.06	0.091	0.32	0.43	0.31
	Range	0-1	0-2	0-5	0-4	0-2	0-1	0-3	0-4	0-1
Licking self *	Av	1.11	2.17	2.23	1.47	0.56	1.59	1.2	1.51	1.69
	Range	0-12	0-1	0-1	0-9	0-4	0-1	0-5	0-6	0-7
Time standing (%)	Av	27.02	25.74	26.53	26.24	31.31	23.81	49.31	46.91	45.00
Time lying (%)	Av	72.98	74.26	73.47	73.76	68.69	76.19	50.69	53.09	55.00
Distance moved (m)	Av	11.8	19.7	27.6	12.8	16.0	16.7	42.4	39.5	80.5
	Range	0-60	0-129	0-269	0-82	0-67	0-48	0-319	0-324	0-282
Time grazing (min.)	Av time	—	—	0.20	0.61	2.26	2.45	4.26	4.96	3.63
	%	—	—	0.6	2.03	7.53	8.17	14.20	16.53	12.10
	Range (min.)	—	—	0-4	0-4	0-9	0-11	0-25	0-24	0-19

* Frequency per calf per 30 min.

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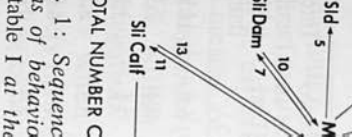

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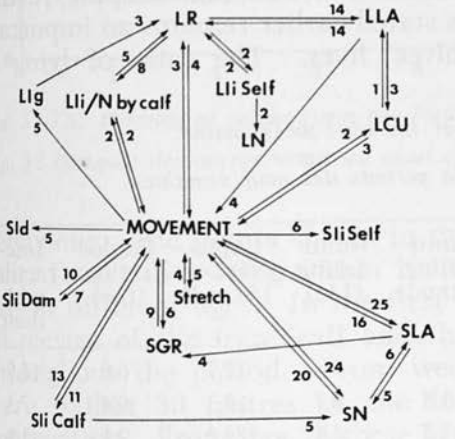
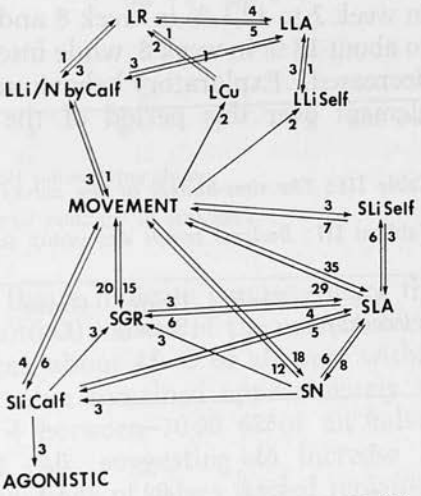
occurred. Calf-peer interaction, on the other hand, tended to increase over the period. Nosing was first seen at 3 days of age and sometimes later became associated with play. At the earlier ages these interactions tended to be single behavioural events but later became chains of behaviour. It can be seen that exploration of the environment in the form of nosing or sniffing objects in the environment was one of the most frequent activities and did not appear to decline over the eight weeks. Comfort movements included stretching scratching with the hind leg and licking self. The frequencies of the last two behaviour patterns are shown. The distance moved was very variable in these samples, but could be in the region of 300 m per half hour. The average distance run per week as a proportion of the average distance moved in that week averaged about 25 % in most weeks. Walking was very frequent and occurred mostly in connection with sniffing the ground. Occasionally long distances were covered. Running, on the other hand, was less frequent but when it occurred longer distances were generally covered. The exact onset of grazing was difficult to determine ; calves were seen in the early weeks to manipulate grass in the mouth in a seemingly exploring manner but not to eat it. Mounting was only seen once in the whole study. When disturbed by a tractor or a person, calves were seen to follow the dam and sometimes to adopt a reverse parallel position with the dam. Most recorded vocalizations by the calf occurred just before or during an interaction with the dam.



TOTAL NUMBER OF TRANSITIONS RECORDED=413

Fig. 1 : *Sequences of first-order transitions of behavioural elements as shown in* table I *at the age of 4 weeks.*

Fig. 1 : *Séquences des transitions de premier ordre des éléments de comportement présentés dans le* tableau I *à quatre semaines.*



TOTAL NUMBER TRANSITIONS RECORDED=313

Fig. 2 : *Sequences of first-order transitions of behavioural elements as shown in* table I *at the age of 8 weeks.*

Fig. 2 : *Séquences de transitions de premier ordre des éléments de comportement présentés dans le* tableau I *à huit semaines.*

Detailed analysis of behavioural sequences were made at 4 and 8 weeks of age *(fig. 1 and 2)*. Focal points of behaviour were assessed in two ways :

— number of connections to other behaviours ;

— % of the total transitions of behaviours.

When considering the number of connections to other behaviours then, at 4 weeks of age, lying resting (LR) was the focal point of lying activities and standing nosing (SN) and standing looking around (SLA) were the focal points of standing activities. When compared with 8 weeks of age, lying locking around (LLA) and LR were the focal points when the animal was lying and SLA was the focal point when the animal was standing. When consideration of point 2 was taken into account, the focal points were essentially the same, with the exception of LLA in week 4 now becoming a focal point with its contribution of 26 % to the total transitions of behaviour occurring while the animal is lying. The other focal points of week 4 were : LR (40 %), SN (13 %) and SLA (12 %). Those of week 8 were : LR (29 %), LLA (37 %) and SLA (21 %). Although the total number of connections did not appreciably decrease with time, the number of behaviours involved in the transitions decreased. This would imply that as the animal matures fewer behaviours are associated in any sequence, and that these show an increase in their degree of association.

The time budget of the calves is shown in *table III*. As would be expected time spent grazing and ruminating increased, grazing from 0.7 % in week 2 to 12,1 % in week 8 and ruminating from about 8 % in week 1 to about 18 % in week 8, while interactions with dam and sleeping/resting decreased. Exploratory behaviour as stated earlier remains an important element over this period of the calves' lives. The ratio of lying to

Table III : *The time-budget of the calves over the nine week period.*

Tableau III : *Budgets temps des veaux sur la période des neuf semaines.*

Age (weeks)	Sleep	Graze (Stand)	Graze (Lie)	Rumi-nating (Stand)	Rumi-nating (Lie)	Explo-ration (Stand)	Explo-ration (Lie)	Inte-racting with dam
0	65.6	—	—	—	—	12.7	6.8	14.9
1	63.4	—	0.7	1.8	8.1	18.3	0.4	7.3
2	53.3	0.1	1.3	1.3	4.4	24.2	9.1	3.3
3	54.1	1.5	0.9	—	10.9	25.9	4.4	2.2
4	48.4	4.8	0.6	0.2	13.0	22.9	4.1	6.0
5	46.2	6.0	1.5	—	23.8	12.2	7.5	2.9
6	21.8	13.9	—	0.7	22.0	24.4	6.0	11.2
7	28.7	13.9	1.0	3.0	18.0	22.3	9.5	3.6
8	27.5	12.5	—	2.1	17.0	23.9	12.0	5.2

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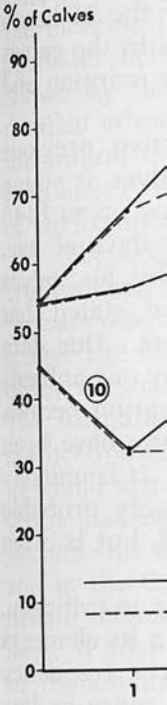

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standing changed markedly in week 6 *(see table II)*. In the previous weeks (0-5) it was fairly constant with about 75 % of the time spent lying but in weeks 6-8 lying decreased to about 50 % of the time. The spatial distribution of the calves when lying shows their tendency to aggregate from an early age *(fig. 3)* and partly reflects their creche

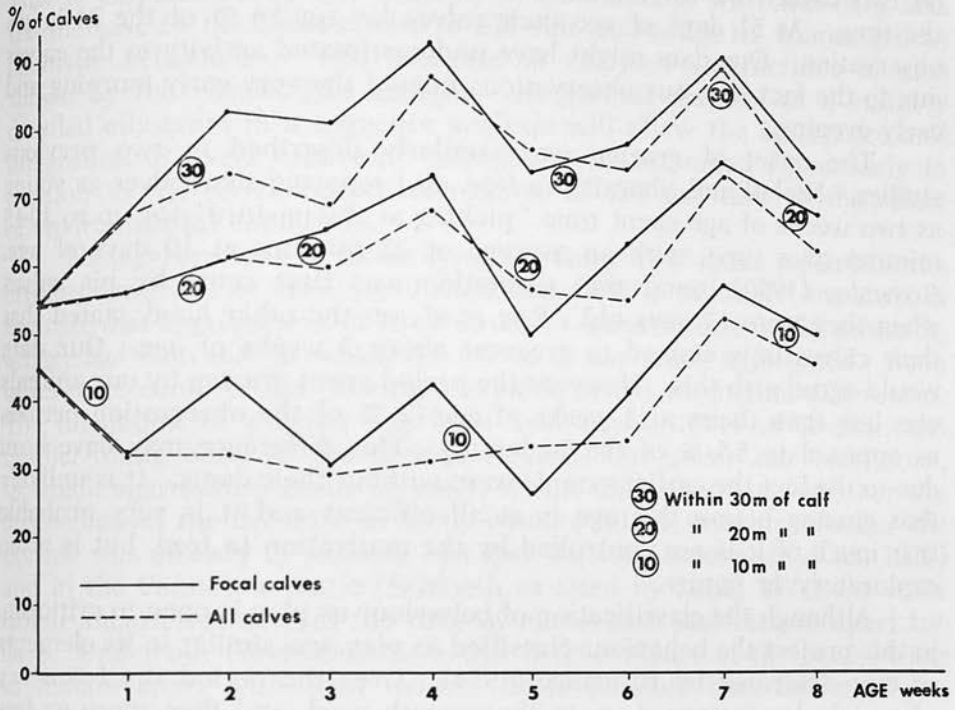

Fig. 3 : *The distance of calves from the focal calf when lying down.*

Fig. 3 : *Distance des autres veaux au veau observé pendant le couchage.*

behaviour. The points shown in that figure indicate percentages of the other focal calves lying within 10, 20 and 30 metres of the current focal calf at different ages. In the first week about 45 % of all were within 10 metres of the focal calf and this value remained approximately so throughout the period. From week 4 between 70-90 % of all calves were within 30 metres of the focal calf, suggesting an increase in aggregation. From day 25 these aggregations of calves tended remained intact when the cows were grazing at some distance away. Further aspects of creche behaviour seen included calves leaving their dams and joining others in locomotory activities, for example on Day 27 a number of calves formed a group walking in file around the edge of the field.

DISCUSSION

Comparing the time budget of these calves with those of others it is seen that lying in our data occupied 45-75 % of the period 0700-1700 hrs — a somewhat higher level than the 38-55 % reported by Nichol and Sharafeldin (1975). Roy *et al.* (1955) in their 12 hours observation on two 20-day old calves found that they lay for a little over 50 % of the time. At 51 days of age their calves lay for 56 % of the 24 hours observation. Our data might have underestimated activity in the calves due to the fact that our observations missed the very early morning and early evening.

The onset of grazing was similarly described in two previous studies. Nichol and Sharafeldin *(loc. cit.)* reported that calves as young as two weeks of age spent time " picking at the pasture " for up to 10-15 minutes at a time, with an average of 23 minutes at 10 days of age. Brownlee (1950) found that vegetation was first eaten by his calves when they were 12 days old. Roy *et al.*, on the other hand, stated that their calves only started to graze at about 3 weeks of age. Our data would agree with this. However the period spent grazing by our animals was less than theirs at 3 weeks of age (2 % of the observation periods as opposed to 5.5 % of the 24 hours). This difference may have been due to the fact the earlier sample were without their dams. It is unlikely that grazing before this age is at all efficient and it is very probable that much of it is not controlled by the motivation to feed, but is often exploratory in nature.

Although the classification of behaviour as play is open to criticism, in this project the behaviour classified as play was similar in its elements to that described by Brownlee (1954). Over the period the frequency of social play increased up to the seventh week and then more or less levelled off. It was commonly linked with locomotory exploration, but in general the calves switched their behaviour rapidly when active so that the underlying motivation is very difficult to assess. A minor deviation was found from Brownlee's description : He describes bucking as first occurring at 6 days while in this study it was witnessed in a 3 day old calf.

Social interactions with peers increased up to week 6 and then, like social play, levelled out. It would be of interest to know more about their social interactions ; whether, for example, they tended to interact more with certain calves at this age than with others. Our results clearly show that, like so many young bovids, they have a high tendency to congregate from an early age and to form a creche. Unfortunately because we could not easily identify all the calves in the population we could not tell whether special relationships existed between calves or not Neither could we say how many different calves our focal calves interacted with. Synchrony and social facilitation were also difficult to assess from our date.

The sequence analysis shows the development of the calf from resting activities at 4 weeks of age to observational and investigatory activities at 8 weeks of age. Grazing also becomes more integrated with the other behaviours at 8 weeks at 8 weeks of age, suggesting that the calf is becoming less dependent on its dam and more integrated with the social structure of the herd and in particular with other calves. This is emphasised by the absence of interactions with the dam and the increase in the connections to SN calf, including its connection to agonistic behaviours. This increase in calf-peer interactions is also shown by the time-budget analysis. In general the use of a suitably detailed ethogram in a sequence analysis will allow the emergence and integration of overt behaviour patterns to be examined rigourously in relation to the physiological maturation of the calf and to the effect of environmental conditions.

The aggregations of calves lying far from their dams resembles the creches described by Arnold and Dudzinski (1978). However, the authors indicate that aggregations of 20 or so calves occur from 6 weeks onwards, a later age than that at which the calves in our study aggregated. Such differences could be due to either to stock or environmental differences. The formation of creches has been said (Lent, 1971) to weaken the mother-young bond in the African Bovidæ, but under our conditions, in which aggregation occurred early, it was difficult to say whether the creche causes the decrease in mother-young interactions or whether the decline was already in process. In *Bos indicus* (Reinhardt *et al.*, 1977) and in the Camargue cattle (Schloeth as cited by Lent., 1971) the cows isolate themselves around the time of parturition and remain apart for days. Under our conditions there was little evidence of the cows trying to remain apart with their calves. It is possible that this need for isolation has been lost in breeds of *Bos taurus* such as ours or that the usual European farm does not have the necessary environmental features to simulate the behaviour. Certainly our calves behaved as true hiders in that they spent long periods lying away from the mother. Altmann (1952) describes variation in hiding behaviour in the elk *(Cervus canadensis* Nelsoni). Some calves are described as following their dams while still wobbly on their legs while some cows forced their calves to lie and remain hidden for considerable periods. Our calves, like the elk, do not fall into a strict hider category. It would seem that there is a graduation in the Bovidæ from the true hiders in which the calf lies alone and is visited by the dams as in the kudu (Lent, 1971) to the true follower like the Wildebeest. Cattle and elk are, in different ways, intermediates within this spectrum.

Overall the results indicate that from the very first week of life the calves engage in a wide variety of activities which include social behaviour, exploration, locomotion and running. Veal calves kept in individual crates are thus deprived of the ability to express the more complex behaviour patterns. Although these activities occupy a very

much smaller part of the day than resting and standing in a time budget they may be an important source of stimulation for the young calves. The lack of this stimulation may be the reason why veal calves often indulged in excessive self licking and other abnormal behaviour described by Kiley-Worthington (1983).

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